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ABSTRACT

This agriculture extension service publication from Pennsylvania State University consists of four sections on plant disease recognition and control. The titles of these four sections are: (1) Some Important Diseases of Tree Fruits; (2) Diseases of Vegetable Crops; (3) Diseases of Crops; and (4) Diseases of Tree Nuts. The first section discusses the various disease causing organisms and gives hosts, symptoms, disease cycle, and control information for the tree fruit diseases which are alphabetized for easy reference. The second section specifically discusses the diseases of beans, crucifers, cucurbits, peas, potatoes, sweet corn, and tomatoes. The third section examines six common diseases of grapes in Pennsylvania. The final section describes Walnut Anthracnose, Walnut Blight, and Filbert Bacterial Blight. (MR)

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SOME IMPORTANT DISEASES OF TREE FRUITS

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DISEASES OF TREE FRUITS CONTROLLED, IN PART, BY PESTICIDES

Apples

Bitter rot
Black rot
Blossom end rot
Blotch
Botryosphaeria rot
Brock's fruit spot
Brown rot
Crown gall
Crown rot
Fire blight
Fly speck
Nectria twig blight
Nematodes
Powdery mildew
Rust diseases
Scab
Soft rot
Sooty blotch
Sooty mold

Pears

Bitter rot
Black rot
Botryosphaeria rot
Brown rot
Crown gall
Crown rot
Fire blight
Fly speck
Nematodes
Pear leaf blight and fruit spot
Pear leaf spot
Rust
Scab
Soft rot
Sooty blotch
Sooty mold

Quince

Black rot
Crown gall
Crown rot
Fire blight
Leaf blight and fruit spot
Leaf spot
Nematodes
Rust
Sooty mold

Peach-Nectarine

Bacterial spot
Brown rot
Crown gall
Leaf curl
Nematodes
Powdery mildew
Prunus stem pitting
Rhizopus rot
Rusty spot (peach only)
Scab
Sooty mold

Plum

Bacterial spot
Black knot
Brown rot
Crown gall
Leaf spot
Nematodes
Plum pockets
Powdery mildew
Prunus stem pitting
Rhizopus rot

Apricot

Bacterial spot
Brown rot
Crown gall
Nematodes
Powdery mildew
Prunus stem pitting
Scab

Cherry

Bacterial canker
Black knot
Brown rot
Cherry leafspot
Crown gall
Nematodes
Powdery mildew
Prunus stem pitting
Rhizopus rot

ORGANISMS CAUSING DISEASE

Diseases are one of the limiting factors in production of fruits and nuts. For some, pesticides are an important means of control. These are described below. They are caused by four classes or types of microorganisms: fungi, bacteria, viruses and nematodes.

Fungi are plants; however, unlike our familiar green plants, they cannot make their own food from water, carbon dioxide, and the sun's energy. The fungi must obtain their food from organic matter of dead plants or from living plants. When the latter occurs, the symptoms of disease are produced on the host plant. Many fungi are mold-like organisms existing in the form of microscopic threads. Most are transmitted from plant to plant by tiny seed-like bodies called spores, which are carried by air currents, splashing water, or tools.

Bacteria are microscopic one-celled organisms. The forms causing plant diseases are rod-like or cylindrical in shape and reproduce by fission; that is, they divide in half, transversely. In this manner, millions of bacteria may be produced in a short period of time. They are carried from place to place by insects, rain, and tools.

Viruses, as we recognize them, are submicroscopic, cylindrical or spherical bodies. They are not living organisms, but rather particles composed of nucleic acids and other compounds that are similar to the chemical make-up of chromosomes of the host cells. When introduced into plant cells, the virus particles are multiplied, often causing severe ill-effects to the plant. Virus particles may be transmitted by insects, nematodes, infected propagating material, or infected pollen. Different viruses may require different means of transmission.

Nematodes are thread-like round worms. Those attacking trees and grapes are microscopic in size and live in the small roots of their host plants or the surrounding soil. Their mouthparts contain a hypodermic, needle-like structure (stylet) used to penetrate the cells of roots. With it, they deliver a digestive juice that predigests the root cell materials, which then are sucked into the nematode. When nematode populations are high, their feeding can result in stunted tree growth. Some cause the plants to produce galls; others produce lesions, which may be entry points for root decay fungi. A few nematode species are capable of transmitting virus diseases.

Nematodes are transported in the roots of infected nursery trees, in soil adhering to orchard equipment, and by the movement of soil water and surface water run-off. Often they occur as a natural part of the soil's varied population of microorganisms.

APPLE SCAB

Hosts: Wild and cultivated apple and crabapple.

Leaves -- The first infections often occur on the leaves surrounding the flower buds. The appearance of dull, smoky areas on the leaf, 8 to 18 days after

infection, is the first evidence of the disease. These areas soon become olive-colored and velvety. As the lesions (infected areas) become older, they assume a definite outline as olive-green or nearly black circular spots. As other leaves develop, they are equally susceptible. Severe early leaf infection can result in dwarfed, twisted leaves, which later drop.

Fruit -- Early infection may occur on the calyx (blossom end of the fruit) or on the pedicel (fruit stem). Severe pedicel infection results in fruit drop. Fruit may become infected at any time in their development. Typical fruit lesions are distinct, almost circular, rough-surfaced, olive-green spots up to 3/4 inch in diameter. Heavily infected fruits are usually misshapen and they may crack and drop prematurely. When leaf infection is active just before harvest, the fruit may become infected. These spots do not show at harvest-time, but they will develop slowly while the apples are in storage. This phase of the apple scab disease is termed storage scab. Infected fruit, when removed from storage, will show numerous, small, black spots. These spots are sometimes confused with bitter pit or ammonia injury.

Disease Cycle -- The apple scab fungus (*Venturia inaequalis*) overwinters in infected leaves that have fallen to the ground. Fruiting bodies are produced within the dead leaf tissue. As spring approaches these begin to mature and produce spores (ascospores) that are discharged into the air currents and carried to the developing apple buds. The fruiting bodies in the fallen leaves must be wet for spore discharge to take place. All the ascospores are not discharged with the first spring rains for they mature over a 4 to 6 week period. This usually coincides with the period from when apple buds show 1/4 inch green until 2 to 3 weeks after petal fall.

When these spores land on wet apple buds, leaves, or fruit and if they remain wet for a few hours, the spores will germinate and send sprouts (germ tubes) into the apple tissue. The time required for germination and penetration depends on temperature and the presence of a wet surface. At 40°F almost 48 hours of continuous wetting is required for infection, while at 65-75°F, only 10 hours are required. After the fungus has penetrated, it continues to grow and enlarge beneath the cuticle. After 8 to 18 days (development occurs most rapidly at high temperatures) a visible scab lesion is produced. On the surface of the lesion more spores (conidia) are produced. These spores are easily dislodged when the lesions are wet. They are splashed around by rain and blown by wind to new leaf and fruit surfaces within the tree. These spores germinate on wet surfaces, infect the tissue, and produce a new lesion. In this manner, several secondary infection cycles may occur in the course of a growing season.

Chemical Control -- Scab infections may be prevented by applications of fungicides at regular intervals throughout the growing season. The object is to provide a protective coating that will inactivate any spores landing on the fruit and foliage. Spray applications are more effective than dusting.

The critical period for scab control is early in the season from bud emergence through second cover period. If scab infection can be prevented during the time all the ascospores are discharged from the fruiting bodies in the fallen leaves, the disease cycle is broken and no further source of infection remains for the rest of the season. However, if control is not obtained, and leaf and fruit infection does occur, then conidia are produced on these lesions and scab will remain a constant threat all season whenever wet weather occurs.

Choice of Fungicides -- Scab control fungicides may be protectants or dual action materials that combine both protectant and eradicant properties. The protectant-type materials must be present on the leaf or fruit surface before the spores land in order to be effective. Materials of this type are ferbam, glyodin, thiram and wettable sulfur. If the germ tube has already penetrated the leaf or fruit these materials will not stop infection.

In contrast, an eradicant fungicide can be applied to the infected surfaces after the infection has occurred and stop the infection process. This property of certain fungicides is quite useful as the grower may apply the fungicide a short time after the beginning of a rain period and still prevent infection.

Some fungicides have combined eradicant-protectant properties. Examples of these materials are benomyl, captan, dodine, Dikar, Glydrex, and Polynam. Dodine and benomyl, when sprayed on existing scab lesions, will reduce spore production in the lesion, a property of great help to the fruit grower.

BACTERIAL CANKER

Hosts: Cherry, peach, nectarine, plum, apricot, apple and pear.

While this disease can occur on all stone fruit trees, and on apple and pear blossoms, it is important only on sweet cherries and ornamental flowering cherries in the Northeastern U.S. It is caused by the bacterium Pseudomonas syringae. Several other names have been used for the same disease; the more common are gummosis and sour sap.

Gumming is common on stone fruit trees, whether on trunks, limbs, twigs, or fruit when injuries and fruit malformations occur. Thus, the name gummosis does not define a cause - only a response. Sour sap often occurs following winter injury to the trunks or limbs, wet feet, and soil-line girdling in the winter or early spring. The sour odor is due primarily to the fermentation of sugars by yeasts under the bark of injured areas. So this term, too, does not describe a cause. Even so, gumming and sour sap conditions are symptoms of the bacterial canker disease.

Symptoms on sweet cherry -- The disease occurs on branches, twigs, buds, leaves, and fruit. The most conspicuous symptoms are the cankers and dying branches girdled by them. The cankers on the twigs are darkened areas often at the base of buds. On the limbs or trunks they often are darker than the normal bark, sunken in their centers, and they may extend for a considerable distance. Gumming is frequent in the spring and fall of the year when the disease is most active. Leaves and shoot growth beyond the canker may wilt and die during the growing season when the cankers girdle a branch or the trunk. Leaf and flower buds are killed during the dormant season, probably as a result of infection during the fall. Small cankers often develop at the base of these dead buds. At times, infected fruiting spurs blossom normally only to wilt and die shortly after.

During periods of cool, wet weather after bloom, leaf and fruit infections may be common. The leaf spots are mostly angular in shape and dark purple, brown, or black in color. The infected areas may drop out leaving a tattered appearance to the leaf, or the entire leaf may yellow and fall. Fruit infection shows as deep, black depressions, as do infections on the fruit stems.

Disease Cycle -- The causal bacterial overwinter in the margins of cankers in the wood and in infected buds. In the spring, during wet periods, the bacteria multiply and ooze from the cankers. They are spread by rains and enter the plant through natural openings or wounds. Periods of frequent rains, cool temperatures, and high winds are most favorable for infection. Frost-injured leaves and blossom spurs and cold-injured trees seem especially susceptible. With the higher temperatures of late spring and summer, disease development stops. At this time the newly formed buds become infected either through the leaf scars or bud scales, or both.

Control -- While bacterial canker can be a severe disease in itself, it is often much more severe on cold-injured trees and on trees growing in sites with poor internal soil drainage.

The causal bacteria can be transmitted by pruning tools so these should be disinfected between trees if bacterial canker is present. Limbs with cankers on light to moderately infected trees should be cut off several inches below the cankered area. This can be done during a warm, dry period of summer, or during the winter when temperatures are freezing or below.

Sprays during the growing season have not been effective in disease control. Some benefit has come from applications made when most of the leaves have dropped in the fall and just before bud swell in the spring. For maximum benefit, these sprays should be continued for several years on susceptible trees.

BACTERIAL SPOT

Hosts: Peach, nectarine, plum, apricot and cherry.

This bacterial disease, caused by Xanthomonas pruni, affects peach, nectarine, plum, and apricot most seriously. Other names for the disease are bacteriosis, shot hole, and spot. The causal bacteria attack fruit, leaves, and twigs. Fruit loss on some cultivars can be very high in occasional years. Early and severe defoliation can affect fruit size and winter hardiness of buds and wood. Bacterial spot is more common and severe when trees are growing in light, sandy soils and when nitrogen is insufficient for normal tree growth.

Symptoms -- The symptoms of bacterial spot are quite different from other diseases of stone fruits. They may be confused, however, with injuries from some spray materials and nitrogen deficiency symptoms.

On the leaves, the disease is noticed first as small, angular spots that are purple, black, or brown in color. The mature spots remain angular and about 1/3 to 1/4 inch in diameter. Often the spots are most numerous at the tip ends and along the midribs of the leaves. While the individual spots are small, several may join thus involving a large part of the leaf. The infected areas may drop out giving the infected leaves a shot hole appearance. Infected leaves eventually turn yellow and drop. There is no apparent relationship between the number of individual spots and the yellowing and defoliation. On plum, the shot hole effect is more pronounced than on the other stone fruits.

Other leafspot diseases and spray injury spots tend to be much more circular in outline. Often, these are not confined by the veins in the leaf as is bacterial spot. Nitrogen deficiency symptom spots are normally red in color.

On peach, nectarine, and apricot fruit, bacterial spot is first noticed as small red or brown surface spots. They may appear anywhere on the fruit, but similar-age infections often are concentrated in the same area. Young spots frequently have a red, green, or light yellow halo around them. As the fruit grows, the spots become black and depressed. Since the infected areas cannot expand with increased fruit size, the spots crack. Fruit infected early in its development will have deep, ugly pits. When the spots are numerous, several deep cracks will develop in the affected area of the fruit.

On plum the fruit symptoms are likely to be quite different. Here, large, black, sunken areas are most common. On a few cultivars, small pit-like spots occur.

There are two distinct twig cankers on peach and nectarine. Summer cankers develop on green shoots in mid- to late-summer. These are small to quite large purple-black lesions, slightly sunken to deeply cracked, and circular to elliptical in shape. Spring cankers develop on the previous season's growth beginning from about the time of bud swell through the bloom period. They may appear as small, somewhat blister-like, darkened areas often around or near a bud. Later, the epidermis ruptures and the bacteria become exposed. Spring cankers also are seen as a tip dieback of the twig and the bacteria become exposed at the junction of diseased and healthy tissues.

The cankers on plums and apricots eventually appear quite different. In the susceptible cultivars of these fruits, the bacteria may survive for 2 or 3 years slowly enlarging and deepening the cankered area. The results are deep-seated cankers deforming the small branches so they have a knotty appearance. Some of these branches may be killed or they may break from the weight of the fruit.

Sweet and tart cherry leaves may be affected by the bacterial spot disease. While rarely happening, the leaf symptoms are like those on peach.

Disease Cycle -- The bacteria overwinter in the twigs or buds. These infections take place in the late summer or fall of the preceding season in peach and nectarine, and result in the spring canker or tip dieback. The time when the bacteria enter the buds or twigs, and under what environmental conditions this occurs, has not been discovered. In plum and apricot the organism does live over in summer cankers, often for at least two seasons.

First infections in the spring can occur anytime after the leaves begin to unfold. Temperatures above 65° F and warm rains are needed for the bacteria to multiply, become exposed, and be disseminated. After these first infections, which are rarely noticed but do initiate the disease each year, the severity of the secondary infections depends entirely on the weather. A moderately warm season with light, frequent rains accompanied by heavy winds favor severe outbreaks of bacterial spot. Any recent injury to the leaves or fruit, such as wind-blown soil particles and hail, may result in severe outbreaks. Twig infections resulting in summer cankers occur in mid- to late summer. The twig, bud, and possibly leaf scar infections that result in spring cankers and tip dieback occur in late summer and fall.

Control -- Maximum use of resistant cultivars is the most effective control measure. There are growing numbers of good peaches highly tolerant of the bacterial spot disease. The leaflet "Peach Varieties for the Seventies," rates many of them as to their susceptibility. Resistance in plums, nectarines, and apricots is not as common. Nurserymen are well aware of the degree of susceptibility of the cultivars they sell and they can provide good information for specific areas. Since trees in poor vigor are more susceptible, orchard management programs should be designed to maintain good vigor. Sanitary measures are of little value.

There are no completely successful spray programs for control of bacterial spot. In seasons when the disease incidence is light, special programs do help. In those when infections are numerous they still reduce the number of infections, but not enough to prevent defoliation and many infected fruit.

BITTER ROT

Hosts: Apple and pear. On peach and nectarine the same fungus causes a disease known as anthracnose; on grape it causes a disease known as ripe rot; and on chestnut a disease known as blossom-end rot of green burs. The discussion below is limited to apple and pear.

Symptoms -- The disease will be seen only on the fruit. Cankers can form on twigs, but they are rare. The fungus does not infect leaves; however, it is one of the few fruit rot organisms that can penetrate the unbroken skin of the fruit. The disease is noticed first, during midsummer or later, as a small, light-brown, circular spot. One or many may appear on a fruit. They enlarge quite rapidly if the temperatures are high and soon change to a dark brown color. By the time the spots are 1/8 to 1/4 inch in diameter they are distinctly sunken or saucer-shaped. When they reach 1/2 inch in diameter, small black dots, the fruiting bodies of the fungus, appear in the sunken lesion. These may be arranged in concentric rings. Later, they ooze a gelatinous salmon-pink mass of spores, which are washed by rains to other fruit. Beneath the surface of the spot, the flesh is light brown and watery in a cone-shaped areas with the small end of the cone toward the center of the fruit. As the fruit ripens, it decays rapidly and finally shrivels into a mummy.

Disease Cycle -- The fungus lives over winter in mummied fruit and in cracks and crevices in the bark. The jagged ends of broken limbs are an ideal site. With the advent of warm weather the fungus produces spores that are washed by rains to the developing fruit. Often the first infections appear in a cone-shaped area on the tree and can be traced to a source of spores at the tip of the cone. The optimum conditions for disease development are rains, relative humidity of 80 to 100 percent, and 85° F. temperature.

BLACK KNOT

Hosts: Plum and cherry.

This disease is well-named since the black, warty knots on branches of infected trees are its most characteristic symptom. Trees with the disease, caused by the fungus *Dibotryon morbosum*, gradually become stunted and unthrifty. Occasionally, limbs may be girdled. This disease is most important on plum and secondarily on cherry.

Symptoms -- The disease is present only in the woody parts of trees, occurring most frequently on twigs and branches and sometimes on trunks and scaffold limbs. The warty swellings first become visible in late summer or following spring on new shoots. At first the knots are somewhat greenish and corky. With age they become black and hard. The knots vary in length from an inch to nearly a foot. Many times they do not completely circle the branch. Those a year or older may become covered with a pinkish-white mold of another fungus as well as riddled with insects, especially the lesser peach borer.

Disease Cycle -- About the time the new season's growth is one-half inch long, spores of the fungus are discharged from tiny sacs in the surface of the knots. These are spread by rain and winds to the new growth where infection takes place. Spore discharge and infection are greatest during wet periods when temperatures range from 55° to 75° F. Infections continue to occur until terminal growth stops. A few greenish, corky swellings may become visible the fall after infection occurs, but most will not be noticed until the following spring. Generally, the knots produce no spores until the second spring after they become visible. The fungus in the woody tissues continues to grow in the spring and fall, increasing the length of the knots. Their eventual size depends greatly on the species and cultivar of the host.

Control -- New plantings of plums should not be made next to old ones with black knot. Wild plums and cherries should be removed from nearby woods and fence rows for at least 500 feet from the new orchard. Once the disease appears in the trees, the knots should be removed. When they occur on twigs and small branches, prune out the infected branches about 4 inches below the knot. The knots on large branches and trunks can be cut out. This is done most successfully during the summer when the fungus does not extend far beyond the visible swelling. Remove the diseased wood and about one inch of clean wood around the knot. Coat the area with a tree wound dressing. The knots should be removed before growth begins in the spring, and taken from the orchard, as they will continue to produce spores for several weeks even after removal. Once the knots have been removed, sprays will control the disease.

BLACK ROT

Hosts: Apple, crabapple, pear and quince.

The black rot fungus, *Physalospora obtusa*, causes a leafspot, fruit rot, and limb canker on apple, and a fruit rot on pear and quince. The fungus will grow and produce its spores on dead woody tissue of many plants, but its parasitic activities are confined mostly to the pome fruits. Losses from black rot result from rotted fruit, defoliation, and loss of limbs by cankers. Fruit rot and leafspot are more destructive in the southern and central fruit growing areas of eastern United States, while the limb canker phase is more destructive in the northern areas.

Symptoms -- Fruit rot usually appears at the calyx end of the fruit. It can originate at any wound that penetrates the epidermis, including those of insect injuries. Ordinarily there is but one spot per fruit, a difference from bitter rot. When first seen, the spots are brown and this color may not change as the area increases in size. Or, the original area may turn black. As the spots enlarge, often a series of concentric bands is formed, the darker bands of mahogany brown to black alternating with brown bands. As it becomes mature, the entire fruit is rotted, turns black, and shrivels into a mummy. The rotted area remains level with the healthy flesh for some time, further distinguishing black rot from bitter rot. The brown flesh of the decayed area is quite firm and somewhat leathery, especially in immature apples. Sooner or later, tiny, black, pimple-like bodies (pycnidia) appear on the surface of the rot. These contain spores of the black rot fungus.

The first evidence of the disease on the leaf, also known as frog-eye, is the appearance of tiny purple specks on the upper surface. These enlarge initially to 1/8 to 1/4 inch diameter circles. The margin remains purple, while the center turns brown, tan, or yellowish brown. Often there is a second enlargement of leafspots. This is not a uniform expansion so the spots become irregular or lobed in shape. By this time the leafspots assume their characteristic "frog-eye" appearance: a purple margin with a zone of dark brown surrounding the tan to gray center. Small, black pycnidia may appear in the centers of the spots on the upper leaf surface.

The infected areas of branches and limbs are reddish-brown in color and sunken slightly below the level of the surrounding healthy bark. The cankers may expand a little each year; a few of them eventually becoming several feet in length. The margins of these older cankers are slightly raised and lobed. The bark in the center of older cankers usually turns light-colored, loosens, and scales off raggedly. This characteristic is not confined to black rot cankers so it is not a good diagnostic symptom. The pimple-like fruiting bodies of the fungus may appear in the bark of cankered areas. However, they are more frequent and much more numerous in the bark of small dead twigs.

Disease Cycle -- The fungus overwinters in tiny, black, pimple-like bodies (pycnidia) in dead bark, dead twigs, and mummied fruit. The fungus can invade almost any dead woody tissue. It is almost certain to invade twigs killed by fire blight. Early leaf infections often are seen in cone-shaped areas of the apple trees, with a dead twig or mummied fruit at its apex.

When the pycnidia become wet, spores ooze from them to become distributed by raindrops; these may infect the leaves, the calyxes of blossoms or tiny fruit, and wounds in twigs and limbs. Infections of fruit and wood may not become visible for several weeks. Throughout the growing season, new infections occur during periods of wet weather. First fruit infections occur during the bloom period, although these are not evident until midseason or later. Throughout the growing season, infections occur through wounds. Harvest injuries may become infected and the fruit decay during or after storage. This is especially true with fruit harvested during a wet period. Leaves are invaded through stomates ("breathing pores" of the leaf) and through injuries such as caused by spray materials. Dead fruit spurs or twigs, especially those killed by fire blight, are invaded. Entry points to limbs are through shoots killed by fire blight, pruning stubs, and areas damaged by winter injury and sun scald.

While a distinct canker phase is not recognized on pear and quince, nor does black rot occur on their leaves, dead twigs and fruit spurs are invaded. These, and mummied fruit hanging in the tree, provide the source of spores for fruit rot. The origin and progression of fruit rot are similar to that on apple.

BLOSSOM END ROT

Hosts: Apple. The causal organism also causes a severe bunch rot of grape.

The disease, caused primarily by the fungus Botrytis cinerea, occurs on the blossom end of apple fruit. The infection likely occurs during bloom, although it does not become visible until several weeks later. The infected area is seen as a small, 1/4 to 1/2 inch diameter lesion next to or including part of the calyx. The spot usually is brown in color, slightly sunken, and often has a red border. A shallow, dry or corky rot develops in the flesh underneath the spot.

The disease appears to be more common in seasons of prolonged cool, wet weather during and shortly after bloom. It has appeared most frequently on Delicious, Rome Beauty, and McIntosh. Blossom end rot on fruit placed in storage often leads to moldy core. This is especially true in Delicious.

BLOTCH

Hosts: Apple and crabapple.

The disease is caused by a fungus, Phyllosticta solitaria, which can infect fruit, leaves and twigs.

Symptoms -- There are two types of leaf spots. The less frequent one occurs on the leaf between the veins as a small, light-gray spot with a dark dot in its center. The more common leaf spots occur on the veins, midribs, and petioles (leaf stems) as long, narrow, slightly sunken, light-colored lesions. These contain several dark dots, the fruiting structures (pycnidia) of the fungus. When petiole infections are numerous leaf drop may result.

New shoot infections first appear similar to the petiole infections except they are longer and are seen more easily. They occur at the junction of the petiole with the shoot (node) or between the nodes. Once the lesion becomes established, it may continue to enlarge for 3 or 4 years, becoming noticeably larger than the diameter of the normal limb. In this manner the organism causing apple blotch becomes established in the tree.

Fruit infections vary in size from small, dark spots to large blotches that may cover much of the fruit surface. Edges of the larger lesions are irregularly lobed with many radiating projections. Large lesions often cause the fruit to crack.

Disease Cycle -- The causal fungus remains alive throughout the year in the twig and limb cankers. The first infections in the spring occur about petal fall on leaves, young fruit, and new shoot growth from spores oozing from the cankers. Secondary infections from spores produced in the pycnidia can occur until late summer. Frequent rains and temperatures above 75° F. favor the disease.

BOTRYOSPHERA ROT

Hosts: Apple, crabapple, pear, grape and chestnut.

This disease, caused by the fungus Botryosphaeria ribis, is most important on apple where it can be seen as a distinct canker on twigs, limbs and trunks. Two types of fruit rot may occur, but there are no leaf infections.

Symptoms -- New infections on twigs and limbs start to become evident by early summer. They appear as small circular spots or blisters. When the blisters rupture, a watery substance spreads over the bark around the area of infection. As the canker enlarges, it becomes slightly depressed. The cankers stop enlarging in late fall. The following spring, some of those in the limbs will continue to grow while others will not. Small, black pimples, the spore-containing structure of the fungus, appear in rings on the smooth surface of the new cankers in late fall or early spring. On older cankers, these may be present throughout

the year. In addition to the wet spots of new cankers, older ones can be distinguished by the scaling of the papery outer bark. Under the surfaces of the cankers, the tissues are watery or slimy and browned. The cankers are not deep, extending at most to the wood.

The fungus causes two fruit rots. One originates from external infections and the other appears to start internally. The external rot first appears as small, brown spots. Often these have a red border and they usually surround the lenticels. The brown center becomes slightly depressed. Meanwhile, under the spot, the flesh begins to decay in pockets that are cup- or egg-shaped. Once these decayed areas begin to enlarge rapidly, the lesion on the skin also enlarges, and this often to one side of the original spot. The decayed areas run together and ultimately the entire fruit is involved in a "soft rot." No fruiting bodies of the fungus can be seen on the fruit, but syrupy beads of liquid may form on the skin. The skin of red apples may bleach during the decay process and become a light brown color. Because of this characteristic, the disease may be referred to as white rot.

This external rot of fruit can be confused with black rot and bitter rot diseases. The decayed apple flesh of black rot is firm and somewhat leathery, the surface of the spot is not sunken, and pimple-like fruiting bodies eventually are present. Botryosphaeria rot is at first cup- or egg-shaped areas of decayed flesh. The rot is soft, the surface of the spot is slightly sunken, and no fruiting bodies form. Bitter rot causes cone-shaped areas of decay, the surface is sunken, and concentric rings of spores form on the surface.

Apples with no external sign of decay may break down rapidly after harvest or after removal from cold storage. The rot is soft and droplets of a clear sticky liquid may form on the skin. Fruiting bodies of the fungus can be seen under the skin if the apples are left at room temperature. The origin of this internal decay is not known.

Disease Cycle -- The fungus overwinters in fruiting bodies on dead woody tissue. During spring and summer rains, the spores ooze from these and are splashed to other parts of the tree. The fungus invades dead wood, fire-blighted twigs and branches especially. It also attacks living twigs, branches, and trunks. Fruiting bodies are formed in all of these, providing a source of spores for further infections. Fruit infections can occur at any time from the bloom period to harvest. Infections in young apples usually are not evident until near maturity. The external rot lesions are found most commonly on the sides of fruit exposed to high temperatures.

BROOKS FRUIT SPOT

Hosts: Apple and crabapple.

Caused by the fungus, *Mycosphaerella pomi*, Brooks fruit spot also is known by the name Phoma fruit spot. The disease is found only rarely in well-sprayed orchards. When the cover sprays are stopped too soon, or when trees are not well-pruned and sprayed, severe losses can occur. Certain varieties, such as Rome Beauty, Stayman, Jonathan, and Grimes Golden are quite susceptible.

Symptoms and Disease Cycle -- The spots on the fruit are small, about 1/4 inch in diameter. They are somewhat irregular in shape, slightly sunken, and often most numerous on the calyx end of the fruit. On red fruit surfaces they are

red to black in color; on green and yellow fruit surfaces they are dark green. These spots may be quite inconspicuous at harvest. Unless the infected fruit are placed in cold storage immediately after harvest, the spots increase in size, become more sunken, and thus more visible.

The disease cycle is much like that of apple scab, except it begins later in the spring. About the time of petal fall, ascospores are discharged from fallen leaves. Just how the fungus gets on the leaves is not known as there is no evidence of the disease on leaves while they remain on the trees. Rain and high humidity favor the spore discharge and infection of the fruit. Infections continue until midsummer, although in decreasing numbers as the season progresses.

BROWN ROT

Hosts: Peach, nectarine, apricot, plum, cherry, apple and pear.

Successful stone fruit production depends on brown rot control. The fungus, Monilinia fructicola, attacks the blossoms, twigs and fruit of peach, nectarine, apricot, plums, and cherries. While blighted blossoms and twig cankers play an important role in the disease, the rot of ripening fruit causes the greatest economic losses. The rot may occur while the fruit is on the tree, or it may not become evident until after storage, in transit, or at retail outlets. Wet, humid weather during the bloom period is ideal to initiate the disease in the spring. When this is followed by wet, humid weather just before harvest, it almost insures a high incidence of fruit rot.

The fruit of apple and pear may become infected and decay. However, this disease is not as common on these fruits as it is on stone fruits.

Symptoms -- Blossom blight - An unnatural wilting and browning of blossoms about the time the petals fall are the first indications of blossom blight. The diseased blossoms appear much like those that were not pollinated. However, when tipped with a finger, the diseased ones will seem stiff and stuck to the pedicel (fruit stem), while those not pollinated are pliable and will fall easily. In a few days the infected floral parts become covered with a powdery mass of gray spores and base of the flower becomes surrounded by a gummy ooze that sticks the flower to the twig.

Twig cankers - The first twig cankers of the season result from blighted blossoms. The fungus grows from the base of the infected blossom to the pedicel and through it into the twig. Here a somewhat elliptical canker is formed, surrounding the blighted blossom. It too becomes gummy and gray tufts of fungus spores are scattered over its surface and around its edges during wet periods. Some of these cankers may girdle the twig resulting in death of the portion beyond the canker (twig blight). The leaves on blighted twigs appear bleached at first, then brown. They often remain attached for several weeks.

Twig cankers also form when the fungus grows from the rotted fruit through the pedicels to the twigs. These cankers have the same appearance as those resulting from blighted blossoms. They are an important site for overwintering of the brown rot fungus.

Fruit rot - Brown rot on the fruit first appears as a small circular spot. Immature fruit resist infection unless injured by hail or insect punctures, except when they touch a blighted blossom, twig canker, or an infected fruit. Occasionally, the fungus will grow from an infected twig into the fruit stem

and to the fruit. As the fruit near maturity, the brown rot fungus easily can penetrate the unbroken skin. The rot progresses rapidly at ordinary temperatures. In as few as 2 to 3 days the entire fruit may be rotted unless slowed by cold storage temperatures. The skin of brown rot-infected fruit remains firm and unbroken. The rotted flesh is mushy-soft. The surface may become covered with a gray powder of fungus spores. Some of the rotted fruit may remain attached to the tree and become a hard mummy. During wet periods of early spring these may produce spores. Other rotted fruit will fall to the ground and, unless they disintegrate completely or become buried, the fungus can remain in them over winter and produce its sexual spores the following spring.

Disease Cycle -- Mummied fruit that dropped to the ground and became partially buried in trash and soil develop small, vase-shaped, tan-colored fruiting bodies (apothecia) in the early spring. Their broad tops are 1/8 to 1/2 inch in diameter and their stems are 1/2 to 1 1/2 inches long. During the bloom period the sexual spores (ascospores) are discharged with force from the inner surface of the vase to drift in air currents. Infection occurs in the blossoms during wet periods as short as 3 hours when the temperature is as high as 70° F. When wet, the mummies hanging in the trees and the surface of twig cankers, especially those resulting from fruit rot, may produce tufts of gray spores (conidia) that also can infect the blossoms. In cherries and plums these are the most common means of overwintering. The spores for the fruit rot phase of the brown rot disease are produced on the blighted blossoms, new twig cankers, and newly infected fruit. Only 2 or 3 blighted blossoms in a tree, and their resultant twig cankers, can produce sufficient numbers of spores for numerous infected fruit should there be wet weather just before or during harvest. Often apparently sound fruit is harvested only to have it rot when it reaches retail outlets due to infections at harvest or during pack-house operations.

Control -- All cultivars of stone fruits can be attacked by the brown rot fungus. Sweet cherry, plum, and nectarine often suffer more severe losses than peach, apricot, and tart cherry. Most of the peach cultivars developed in the last 20 years are less susceptible than many of the older ones. The U.Ed. 0-785 leaflet, "Peach Varieties for the Seventies," The Pennsylvania State University, lists the degree of brown rot susceptibility for many peaches.

Most of the brown rot control efforts will need to be spent in sanitation practices and fungicides. All fruit remaining on the trees after the last picking should be removed. This will reduce the number of twig cankers in which the fungus may overwinter. Cutting out blighted twigs when they are seen, but no later than normal leaf fall, also will reduce the overwintering sites. During early spring pruning the trees should be thinned out to aid in rapid drying and thorough spray coverage. Any remaining mummies should be knocked to the ground. A light cultivation just as the first blossoms open will disturb the partially buried mummies and prevent them from producing ascospores. The fungicide program must be designed to protect the opening blossoms and the fruit, especially just before and during harvest.

Losses from brown rot in harvested fruit can be reduced by the rapid removal of field heat from the fruit. This is done most efficiently by hydrocooling where the volume of fruit warrants the equipment cost. However, brown rot spores in dirty hydrocooling water can infect otherwise sound fruit. Fungicides may be added to the water or to waxers in the pack-house line to disinfect the surface of the fruit. Following removal of field heat from the fruit, they need to be kept refrigerated until purchased for consumption or processed.

CHERRY LEAFSPOT

Host: Cherry

The fungus causing cherry leafspot, Coccomyces hiemalis, attacks the leaves, leaf stems, fruit, and fruit stems of tart, sweet, and English Morello cherries. The disease is most severe on leaves and may cause them to drop prematurely. When defoliation occurs before harvest, the fruit fail to mature normally, being light-colored and low in soluble solids. The buds and wood become susceptible to winter injury, which may show the next season as poor growth, dead spurs, and dead limbs.

Symptoms -- The disease first appears on the upper sides of leaves as tiny, red to purple, circular spots. These enlarge to 1/8 to 1/4 inch in diameter, becoming red-brown to brown. By then, the spots show brown on the undersides of the leaves and during wet periods tiny, whitish, felt-like patches appear in their centers. These contain the spores (conidia) of the causal fungus. The spots on sweet cherry leaves tend to be somewhat larger. Some of the spots may drop out, leaving a shot holed appearance.

After the leaves become infected, they turn yellow and fall. This yellowing and dropping often is confused with the cherry yellows virus disease, which may cause a heavy leaf drop in June or early July. Leaves from yellows-infected trees are a mottled green and yellow with few if any of the spots characteristic of cherry leafspot.

Disease Cycle -- The fungus overwinters in diseased leaves on the ground. About bloom time, or shortly after, the sexual spores (ascospores) mature and are discharged. They are blown to young, expanded leaves where infection takes place through the stomates on the underside of the leaf. These first infections often are so few in number they are overlooked. However, the conidia from the felt-like centers of the spots on the undersides of leaves will be matured in 10 to 15 days after the first infections. They are spread by rains. Each succeeding wave of infection becomes heavier and severe defoliation begins.

Control -- Rotary mowing the orchard after leaf drop in the fall and fall application of nitrogen, if any is necessary, will hasten the decay of the leaves and reduce the numbers in which the fungus can overwinter. A light discing around the trees just before bloom also decreases the ascospore discharge of the cherry leafspot fungus, as well as the brown rot fungus. The main control of the disease comes from the use of fungicides.

CROWN GALL

Hosts: Peach, nectarine, apricot, plum, cherry, apple, pear and quince.

This disease is caused by a bacterium, Agrobacterium tumefaciens. It can attack many different plants as well as all fruit trees. Peach and Mazzard cherry rootstocks are especially susceptible. The disease is common in tree fruit nurseries and eventually occurs on large numbers of trees in the orchards.

Symptoms -- The disease is readily recognized by wart-like swellings or galls on the roots and crown. Occasionally, the galls may be seen above ground on trunks or branches. Young galls are light in color and cheesy in texture. They become dark and hard with age and may be 1/2 inch to 3 or 4 inches in diameter. When the galls are numerous or when they are located on major roots or the crown, they may disrupt the flow of water and nutrients. The trees then will show reduced growth, an unhealthy appearance, and possibly nutritional deficiency symptoms.

Disease Cycle -- The bacteria causing crown gall are distributed widely in many soils. They can attack a very large number of different kinds of plants. In addition, soils may become contaminated by planting nursery stock dug from contaminated fields. Once in the soil, a few of the bacteria survive for several years in the absence of host plants.

The bacteria must have a wound in order to enter the plant. The more common wounds serving as entry sites are those made during the nursery digging and tree planting operations, tillage equipment, and the injuries made by root-feeding insects and nematodes. Once a gall is initiated, the bacteria play no further part in its growth and development. In this respect, crown gall has been called a plant cancer. Secondary galls may develop a considerable distance from the initial infection. These too are formed in the absence of the crown gall bacteria, apparently due to a tumor-inducing substance, produced at the site of the original infection.

Soil fumigation can play an important role in control of this disease, especially in nurseries.

CROWN ROT

Hosts: Most common on apple and pear.

The fungus-induced crown rot is caused by Phytophthora cactorum. Several other disorders have similar symptoms and often are termed collar rot or crown rot in error. The more common of these are fire blight when it enters rootstock suckers, a drought-induced winter injury, a south or southwest side winter injury brought about by fluctuating winter temperatures, stem grooving virus, brown-line decline virus, and rootstock-scion incompatibility.

Symptoms -- Initially cankers are produced underground in the area of root attachment to the crown, the below-ground portion of the trunk. From this point the cankers may spread out in the roots and up the trunk to or above the soil line. If the scion cultivar is susceptible, such as Grimes Golden, the cankers may progress past the bud union. Otherwise, they do not and often they cease their upward growth at the soil line or, at the most, 4 to 6 inches above it. Tissues under the bark of young cankers turn brown and become gummy. The border between diseased and healthy tissue is marbled light to dark brown. Above the soil line the outside of the bark may appear wet. As the canker ages, the bark often cracks at the margin and becomes slightly sunken, especially when callus tissue is laid down around the lesion. The margins of the canker are usually lobed. When the bark just outside the lobes is cut away it is not unusual to find pockets of brown tissue that are not evident externally.

The cankers girdle the roots and the trunk. Tree top symptoms are reduced growth and yellow to reddish-purple leaves. The trees may decline for a period of 2 to 3 years or they may die during the season above-ground symptoms appear. The disease is most active on trees 3 to 10 years of age.

Disease Cycle -- The fungus causing crown rot lives in the soil. It can survive long periods of unfavorable conditions in thick-walled spores. It has a wide range of hosts and presumably may be present in most soils suitable for fruit trees. Once trees are infected, it can survive in the margins of the cankers as well. In the fall and spring, during periods when soils are saturated with water, swimming spores are formed. These move in the water film to new potential points of infection.

Control -- Careful selection of orchard sites with respect to internal drainage oftentimes prevents damage by collar rot. Draining wet areas of otherwise good orchard sites should be considered. There are susceptibility differences in rootstocks. Apple rootstocks of Melba, McIntosh, and Wealthy seedlings appear resistant. Delicious seedlings generally are moderately resistant. Of the colonial rootstocks, EM IV, EM IX, and EM 26 seem resistant; EM II, EM VII, and MM III are susceptible, and MM 104, MM 106, and EM XI are very susceptible.

Most pear rootstocks are susceptible to collar rot. These often include seedlings of domestic and imported French and Old Home pears (*Pyrus communis*), and Japanese pear (*P. serotina* [*P. pyrifolia*]). Quince and *P. calleryana* rootstocks are resistant.

By the time above-ground symptoms show, the disease is often too well established to eradicate it and save the tree. However, if more than half the circumference of the tree is alive, inarching one-year-old resistant seedlings may be successful. This procedure is the same as that applied to trunks injured from other causes. Chemical control has been but partially effective when applied after infections occur. They likely would be more effective if applied as a preventative treatment.

FIRE BLIGHT

Hosts: Apple, crabapple, pear and quince.

Fire blight is a destructive disease of apple and quince, and is the most serious pear disease in the eastern United States. The causal bacterium, *Erwinia amylovora*, can attack some 75 species of plants of the rose family. In addition to the above pome fruits, fire blight occurs frequently on pyracantha, spirea, hawthorne, and mountain ash. On fruit trees, the disease can result in the death of blossoms, fruit, shoots, limbs, and tree trunks.

Symptoms -- The disease often appears first in the spring as blossom, fruit spur, and new shoot blight. Infected blossoms wilt rapidly and turn light to dark brown. The bacteria may move through the pedicel to the fruit spur and out into the leaves. Here they follow the midrib and main veins, which soon darken. The leaves wilt, turning brown on apple and quince and dark brown to black on pear. The blighted leaves remain attached for much, if not all, the growing season. Some remain even after normal leaf fall.

Shoot blight begins with the infection of the young, succulent growing tip. It may occur any time during the season while the shoots are still growing when environmental conditions are optimum for the disease. The leaves wilt rapidly, turn dark, and remain attached as in the case of spur blight. A characteristic symptom of shoot blight is the bending of the terminal growth into the shape of a shepherd's crook. Pearly or amber-colored droplets of

bacterial ooze often are present on diseased blossoms, fruit, and leaf stems, on succulent shoot stems, and on the exterior of infected fruit. These droplets contain millions of bacteria, which may cause new infections.

The fire blight bacteria can move from blighted spurs and shoots into the larger limbs and tree trunks. Infected branches may be girdled resulting in the loss of the entire branch. Suckers at the base of trees often are invaded. These may blight back to the trunk or rootstock resulting in the loss of the entire tree in one season. This is especially true on susceptible pears and certain clonal apple rootstocks.

Fire blight cankers occur on small to large limbs, trunks, and even roots. They often begin at the bases of blighted spurs, shoots, and suckers. The cankers are slightly sunken areas of various sizes, surrounded by irregular cracks. Active blight cankers are characterized by an amber or brown exudate on their surfaces or on the bark below them.

The fire blight bacteria may invade the fruit, which becomes water-soaked. Droplets of bacterial ooze will appear on the surface. The fruit later becomes leathery, turns brown on apple and black on pear and quince, shrivels, and usually remains attached to the fruit spur.

Disease Cycle -- The bacteria overwinter in the margins of cankers on branches and trunks. Once the temperature reaches about 65° F., they begin to multiply and appear on the outside of the cankers in drops of clear to amber-colored ooze. The bacteria are spread to blossoms or succulent new growth by insects or rain. If the temperature is 65° F. or above, and the relative humidity is 60% or more, or there is rain, new infections can occur. At 75° F., blossom blight and shoot blight will be evident in 4 to 5 days. Bacterial ooze appears on the new infections soon after the symptoms. This provides additional sources of bacteria for new infections. In early to midsummer, during prolonged periods of muggy weather, blighted shoots and spurs, infected fruit, and new branch cankers all may have droplets of ooze on them.

The bacteria enter the flowers primarily through natural opening. Wounds and natural openings are important entry points to leaves, shoots, and fruit. Insects with piercing mouthparts, such as aphids and leafhoppers, may transfer the fire blight bacteria directly into susceptible tissues. The feeding wounds of other insects can serve as entry points. Wounds from hail often lead to a severe outbreak of fire blight. Any fresh wound can serve as an entry point.

LEAF CURL

Hosts: Peach and nectarine, primarily.

Leaf curl on peaches and nectarines is caused by the fungus Taphrina deformans. The fungus mainly attacks the leaves, but on occasion new shoot growth and fruit may become infected. Flowers may be invaded, but they drop soon after opening showing no distinctive symptoms.

Symptoms -- The infected leaves show symptoms soon after they unfold. They become crinkled or puckered, thicker than normal with a leathery feeling, and light-green, yellow, red, or purple in color. The entire leaf or any part of it may be infected. In severe outbreaks of leaf curl, nearly all the leaves on a tree are infected. More often, only the leaves of occasional buds scattered throughout the tree will be diseased. By late spring or early summer, their upper surfaces turn grayish and take on a powdery appearance due to the production of fungus spores. Dry, warm weather soon causes the leaves to turn brown to grayish-black and fall from the trees.

Infected new shoots grow slower than normal, are somewhat swollen, and are pale yellow in color. Severely infected young fruit become misshaped and seldom remain on the tree. Lightly infected fruit mature normally, although they will have one or more wart-like, irregular growths on them. These have no fuzz and are usually reddish in color. They are similar to the irregularities that occur along the suture of some cultivars, for example the Rio Oso Gem and Sunhigh peaches.

Disease Cycle -- The spores produced on the infected leaves are blown or splashed to the newly forming buds, the cracks and crevices of the twigs and bark, and the waxy coating of the new shoots. Here they live harmlessly, occasionally producing new spores when weather conditions are suitable. These too are spread throughout the tree by wind or rains. In the early spring, just as the buds begin to swell, should a spore become lodged in the bud, it may germinate. Thus, all the tiny young leaves may be infected before they unfold, as may the flower or fruit. New shoot infection results from diseased terminal or lateral buds.

Only young, tender tissue can be infected so there is little secondary spread of the disease. Cool, slow growing conditions that prevent rapid bud swell and leaf growth plus wet periods are necessary for severe outbreaks. These can occur, even though the disease has not been noticed for several seasons, as the fungus is nearly always present on the waxy coating of the twigs.

NECTRIA TWIG BLIGHT

Hosts: Apple twigs.

Nectria twig blight is a minor disease that breaks out occasionally. It needs to be recognized since it appears much like fire blight, a very serious disease of apples and pears. The chemical controls for fire blight would be wasted on nectria twig blight, caused by the fungus Nectria cinnabarina.

Symptoms -- In early summer the leaves and shoots on infected twigs wilt and turn brown. A close examination will show a canker has girdled the twig at the point of shoot growth initiation. Most often this will be located at the base of the previous season's cluster-bud. Rome Beauty, which is characterized by enlarged cluster-bud bases, is very susceptible. In midsummer, a few pink or coral fruiting structures of the fungus may appear in the cankered area.

NEMATODES

Hosts: Peach, nectarine, apricot, cherry, plum, apple, pear and quince.

Most of the many species of nematodes living in the soil do not attack plant roots. A few can injure fruit trees seriously when their populations become sufficiently high. The only symptom of attack likely will be reduced growth and vigor of the trees. Nematodes may be important as vectors of disease, such as is the case in transmitting the Prunus stem pitting virus. Injuries made by nematode feeding can provide the entry sites for other disease organisms, such as the bacteria that cause crown gall and the fungi that cause Verticillium wilt.

Control -- Preplant and postplant soil fumigants may be used to control nematodes. Growers should contact their state Extension service about a soil analysis to determine the kinds of populations of nematodes in orchard soils. Various suggested treatments then can be made, depending on the individual situation.

PEACH SCAB

Hosts: Peach, nectarine and apricot.

Caused by the fungus Cladosporium carpophilum, the disease known as peach scab occurs on peach, nectarine, and apricot. It often is severe on the fruit.

Symptoms -- Scab occurs on fruit, leaves, and twigs. It is of primary concern on the fruit. Here the disease is seen first as tiny, poorly defined, olive-black spots on the skin. The disease normally becomes evident about 10 to 12 weeks after shuck fall and new infections may continue to appear until harvest. The spots often are most numerous on the stem end of the fruit. They enlarge very slowly, become distinct, circular, and black. They eventually reach 1/8 to 1/4 inch in diameter. The lesions on apricot fruit are more brown than black. Where the infections are so numerous as to run together, the fruit may crack during its final swell before harvest. The spots themselves are superficial, never penetrating below the epidermal layer of cells. They can be distinguished from bacterial spot lesions as these do penetrate slightly below the epidermis.

In the orchard, twig infections are important only as overwintering sites for the fungus. These show on the current season's growth as circular to oval, tan to purplish-red spots. The diseased area is raised slightly. When they are numerous, the bark may crack and the twig becomes dehydrated and killed. This is most likely to happen on trees just dug from nursery fields. Leaves may be attacked, but these are seldom noticed. The infected areas become olive-green, diffused, small blotches located between the main veins. Long, narrow, brown lesions may develop on the midrib of the leaf. When these are numerous some defoliation will occur.

Disease Cycle -- The fungus overwinters in the twig lesions. About the time of the shuck fall, and up to 6 weeks after, spores are produced in the centers of these lesions. They are washed or splashed to the fruit, leaves, and new shoot growth. Some 6 weeks or more after infection takes place, the lesions become evident. This long delay between the time of infection and appearance of symptoms often puzzles growers when they attempt to evaluate the reasons for an outbreak of scab.

PEAR LEAF BLIGHT AND FRUIT SPOT

Hosts: Pear, quince and apple.

The name of this disease should not be confused with the fire blight or leaf-spot diseases of pears. Leaf blight and fruit spot are caused by the fungus Fabraea maculata. The fungus infects leaves, fruit, and shoots of pear and quince and the leaves of apple. The disease can build up rapidly, even in orchards where it has not been a problem. When conditions favor the disease, and it is not controlled, pear trees may become defoliated in a few weeks.

Symptoms -- Leafspots first appear as small purple dots on the leaves nearest the ground. They increase in size to about 1/4 inch diameter circular spots, becoming purplish-black or brown in color. A small black pimple appears in the center of the spot. When the leaf is wet, a gelatinous spore mass oozes from the pimple giving the spot a creamy, glistening appearance. Each leaf may have dozens of spots resulting in extensive defoliation. Fruit lesions are much like those on the leaves, but they are black and slightly sunken. They may be so numerous as to run together and cause the fruit to crack.

The lesions on the twigs occur on the current season's growth. They are purple to black in color with rather indefinite margins. The lesions may run together forming a superficial canker.

Early defoliation results in small fruit, weak bud formation, and fall blossoming. Infected fruit have no sale value and often are cracked and misshapened.

Disease Cycle -- The sexual spore stage develops on fallen, overwintered leaves. Conidia, asexual spores, also may develop in the spots on overwintered leaves, or they may be produced in the previous season's shoot infections. Often, the first infections do not occur until mid-June to the first of July. Secondary infections begin about one month later and reoccur throughout the season during periods of rains.

PEAR LEAFSPOT

Hosts: Pear, quince, apple.

The pear leafspot fungus, Mycosphaerella sentina, infects the leaves of pear, quince, and occasionally apple. Numerous leafspots can result in defoliation. Fortunately, this does not occur often before fall, except in nurseries.

Symptoms -- Mature leafspots are recognized easily by their grayish-white center with sharply defined margins. They appear first on the upper leaf surface as small, brown lesions and enlarge to 1/8 to 1/4 inch in diameter. The borders become dark brown and small, black pimples appear in the center of the spots.

Disease Cycle -- Sexual spores are produced on the overwintered, fallen leaves. They are carried by air currents to the newly-formed leaves. About a month after infection, new spores are produced in the centers of the grayish-white leafspots, from which they are washed by rains to other leaves. The peak of these secondary infections usually occurs in late summer or early fall.

PEAR SCAB

Hosts: Pear.

This disease resembles apple scab in nearly all respects, and is caused by the closely related fungus Venturia pirina. Pear scab is not particularly common, although it is very destructive when it occurs. The symptoms and disease cycle are so similar to apple scab (pages 1 and 2), they need not be repeated here. A major difference is the frequent appearance of pear scab on twigs, where it can overwinter and initiate new infections in the spring. Leaf infection of pear is not as common as apple scab on apple leaves.

PLUM LEAFSPOT

Hosts: Plum

This disease of plums and prune-type plums is caused by the fungus Coccomyces prunophorae. The fungus, its life cycle, and the disease are very similar to the cherry leafspot disease. The spots on plum leaves tend to be smaller and severely infected leaves often have a tattered appearance. Unlike cherries, heavy plum leaf infection often is followed by a heavy fruit drop.

Most cultivars are susceptible to the disease, so fungicide sprays and the sanitation suggestions presented in the cherry leafspot discussion are needed for control. As the overwintered spores on the leaves are ready for discharge about the time of shuck fall, light discing should be done just before then.

PLUM POCKETS

Hosts: Plum

There are a number of diseases of stone fruit caused by fungi similar to the leaf curl fungus. Commercially, the most important one in the Northeastern U.S. is a disease of American-type plums known as plum pockets or bladder plum. It is caused by Taphrina communis.

Symptoms -- First evidence of the disease on the fruit are small, white blisters. These enlarge rapidly, soon involving the entire fruit. The fruit becomes spongy and the tissues of the seed cavity wither and die. The fruit enlarges rapidly, becoming up to 10 times normal size, reddish in color, and so misshapen that they hardly are recognized as plums. As the spongy interior dries up, the color of the plums becomes velvety-gray due to the production of spores on their surface.

New shoots and leaves usually are infected as well as the fruit. The shoots become much thickened and often curled or twisted. Diseased leaves are thickened and curled as described for leaf curl.

Disease Cycle -- Spores of the fungus overwinter on the twigs. During cool, wet periods of early bloom, they may be splashed to the opening buds where infection takes place. With the development of the ascospores giving the infected fruit a velvety-gray appearance, the disease cycle is completed.

POWDERY MILDEW OF APPLE

Hosts: Wild and cultivated apple and crabapple

The causal fungus (Podosphaera leucotricha) attacks buds, blossoms, leaves, new shoots, and fruit. Powdery mildew interferes with the proper functioning of the leaves, reduces shoot growth, reduces fruit set, and produces a net-like russet on the fruit of some cultivars. It is often a serious problem in apple nurseries.

Symptoms -- The first sign of the disease in the spring is a 3 to 4 day delay in the opening of infected buds. The leaves and blossoms of these buds soon become covered with a white to light gray powder, the spores of the powdery mildew fungus. The flowers do not develop normally, are likely to be greenish-white in color, and will set no fruit. The first symptoms on leaves of new shoot growth are felt-like, white patches of the fungus on the margins and lower surfaces. Infected leaves curl upward and soon become covered with a powdery coating of fungus spores. New infections of succulent leaves and growing shoots cause the entire shoot to be reduced in size. By midsummer, these leaves and shoots may turn brown. The fruit of some cultivars may show a net-like russet as a result of infection that occurred during the blossoming stage.

Disease Cycle -- The fungus overwinters as mycelium (fungus threads) inside infected buds. As these buds open in the spring, all of their parts become covered with a powdery coating of spores. The spores are easily windblown and they serve to infect new leaves, fruit, and shoots. Fruit infections occur during and shortly after the blossom period. Leaf and shoot infection may continue as long as shoot growth continues. Bud infection occurs from the time the buds begin to form until they are matured for overwintering. Disease development is favored by the absence of rain, but by high humidities and temperatures of 65° to 80° F.

Chemical Control -- Protective mildew sprays must begin with the delayed opening of the infected buds. Where the disease is severe, mildew fungicides need to be continued until new shoot growth stops or about the fourth cover spray.

POWDERY MILDEW OF CHERRY AND PLUM

Hosts: Cherry and plum.

The disease is caused by *Podosphaeria oxyacanthae*, one of the common species of the powdery mildew group of fungi. This same fungus has been reported to cause powdery mildew on peach, apricot, apple, pear, quince, persimmon, and a few ornamental plants. This discussion is limited to the disease on plums and tart and sweet cherries.

Symptoms -- The fungus attacks leaves and twigs producing symptoms much like powdery mildew on apple. Infected leaves curl upward. Newly developed leaves on new shoot growth become progressively smaller, are generally pale in color, and somewhat distorted. New shoot growth is shorter than normal. By mid-season the whitish fungus growth can be seen growing over the leaves and shoots, sometimes in patches and other times covering most of the new growth. These symptoms are especially common in nurseries.

Disease Cycle -- The fungus may overwinter on diseased, fallen leaves, but it does so more commonly in infected buds as in the case of apple powdery mildew. When infected buds expand in the spring the new growth becomes overrun by the fungus. Much of the visible white growth consists of conidia, which are spread by wind to other new leaf and shoot growth. Warm temperatures without rain, but with sufficiently high humidities for morning fog or dews are ideal for rapid increase of the disease.

POWDERY MILDEW OF PEACH, NECTARINE AND APRICOT

Hosts: Peach, nectarine, apricot and some woody ornamentals, especially roses.

This disease, sometimes called rose mildew, is not often serious. The causal fungus, Sphaerotheca pannosa, attacks the leaves, twigs, and fruit.

Symptoms -- On fruit, the disease first appears as round, whitish spots two to four weeks after shuck fall. The spots increase in size until much of the fruit is involved. The white spots are due to the fungus mycelium and its spores. About the time of pit-hardening, the skin of the fruit under the spot turns pinkish and the fungus and its spores disappear. Eventually the skin becomes leathery or hard, turns brown, and may crack.

Diseased leaves often fail to unfold normally, while the ones on new shoot growth become narrow, strap-like, and distorted. New shoots are shorter than normal and distorted. The white mycelium and spores of the fungus may cover the infected leaves and shoots or they may appear in whitish patches.

Disease Cycle -- The fungus overwinters on shoots infected the previous season. Quite likely it hibernates behind the leaf bud scales. Flower buds on infected shoots often do not survive the winter. As the leaf buds expand in the spring the young leaves become infected and the spores produced on these leaves serve to infect the young fruit, new shoot growth, and newly expanding leaves.

PRUNUS STEM PITTING VIRUS

Hosts: Peach, nectarine, apricot, cherry and plum.

Prunus stem pitting can attack all stone fruit trees, resulting in a girdling of the trunk and eventual death of the tree. Diseased trees do not recover.

Symptoms -- Leaves of infected trees show the first external evidence of the disease, usually in late summer. On a single or several shoots, one or more branches, or rarely much of the tree, the leaves become pale green, cup upward along the midrib, turn various shades of yellow through red to purple and then begin to drop from the tip back towards the main branches. The following season, the tree will appear weak, growth will be stunted, many of the flower buds will have been killed during the dormant season. The few fruit that set will be misshapen; they will ripen prematurely and have an insipid taste. Eventually, the infected trees die or they may break off near the groundline during heavy winds.

The above symptoms are, at least in part, similar to those of trees girdled from other causes. To further identify Prunus stem pitting it is necessary to remove a strip of bark from a few inches above the ground to 6 to 8 inches below the groundline on the trunks of suspect trees. On infected trees, the bark and sapwood will be much thicker than normal. The wood will have elongated indentations, pits or swellings. The degree of pitting depends on the kind of stone fruit tree, its scion and rootstock, and the stage of disease development.

A poorly developed root system results from severe virus infection of trees. Often many of the roots will be on one side of the crown. When the trees are pulled, socket-like depressions remain in the crown where the roots break away. Trees broken over reveal a serious disorganization of the woody tissues. This disorganization results not only in a structurally weak tree, but also produces the girdling effect resulting in the above ground symptoms.

Cause -- Prunus stem pitting is caused by a virus of the tomato ringspot group. The virus is soil borne and is transmitted to healthy trees by a species of dagger nematode. Soil fumigation plays an important role in the control of this virus disease, both in nurseries and orchards.

RHIZOPUS ROT

Hosts: Peach, nectarine, sweet cherry and plum.

This disease, caused by the "bread mold" fungus Rhizopus nigricans, can be very destructive on harvested fruit. While it can develop in hail-injured, or cracked fruit on the tree, it is most common during storage, transit, and at the marketplace. Peach, nectarine, sweet cherry, and plum are most susceptible.

Symptoms -- The beginning of the rot is much like that of brown rot - a small, brown, circular spot. There is a detectable difference. The skin of Rhizopus rot-infected fruit slips readily from the underlying flesh, while the skin of brown rotted areas is tough and leathery. At normal temperatures, the small spots of Rhizopus rot enlarge rapidly and can involve the entire fruit in 24 to 48 hours. A white, whiskery, mold appears on the surface of the infected fruit, spreading to nearby fruit and the walls of the container. By this time the fruit often begins to leak and to have a vinegar-like odor. Finally tiny, black, spherical structures are produced on stalks above the white mold growth. Each of these contain thousands of spores (sporangiospores) that are released to float in the air. At this stage the mold appears mostly black.

Disease Cycle -- The Rhizopus rot fungus occurs on all decaying vegetation, including ripe fruits and vegetables. When environmental conditions are not favorable, it produces thick-walled zygospores that can withstand long periods of cold and drying. These are present on dead vegetation, in used fruit containers, and in pack-houses and storages. Thus, some type of spore of the Rhizopus rot fungus is ever present where fruit are handled.

An injury through the skin of the fruit must be present for the first infections to occur. Injuries as tiny as the prick of a pin are sufficient. In packed fruit, or clustered ripe fruit on the trees, the fungus can spread over the uninjured skin from an infected neighbor and eventually cause a rot. High temperatures and humidities favor the rapid growth of the fungus and decay of fruit.

Control -- Prevention of skin cuts and punctures during harvest and packing is the prime consideration in control of Rhizopus rot. Clean containers and good housekeeping in the pack shed and storage will aid greatly in reducing the spore population. Quick removal of the fruit field heat drastically slows the advance of decay as does maintaining the fruit under refrigeration until it is sold to the consumer or processed. A fungicide may be applied to the fruit prior to harvest if they are not to go through a water system in the pack-house. Or, it can be added to the water dump, hydrocooler, or water. To be effective, the water must be changed frequently.

RUST DISEASES

There are three rust diseases. The most common is cedar-apple rust. All three must spend part of their life cycle on red cedar. Only the cedar-apple rust is described, as the others are somewhat similar.

Hosts: Cedar-apple rust - leaves and fruit of apple and crabapple.
Hawthorne rust - leaves of pear, hawthorne, apple and crabapple.
Quince rust - leaves and fruit of quince; fruit of pear, apple and crabapple.

The diseases can cause economic loss in several ways. Severe leaf infection and defoliation may result in trees becoming susceptible to winter injury. Severe defoliation will reduce the size and quality of the fruit. Infected fruit will be deformed, sometimes very severely.

Symptoms -- On leaves, cedar-apple rust, caused by the fungus Gymnosporangium juniperi-virginianae, first appears as small, pale-yellow spots on the upper surface. The spots enlarge to about 1/8 inch in diameter. Eventually, tiny black, fruiting bodies called pycnia, become visible in these spots. Often a number of orange-yellow protuberances, called aecia, are produced in each spot on the underside of the leaf. Infected leaves may remain on the tree, or they may become yellowed and drop.

Fruit lesions appear on the blossom (calyx) end. They are somewhat like the leaf lesions, but much larger. They often cause the fruit to be disfigured or to develop unevenly. Aecia, like those on the undersides of leaves, may develop in the fruit lesions.

Light-brown to reddish-brown galls form on the branches of red cedar. When they are dry and hard they may be 1/2 to 2 inches in diameter and are known as "cedar apples." The surface of the galls are covered with depressions much like those on a golf ball. In the spring, when the "cedar apples" become wet, a yellow, gelatinous horn (telial horn), up to 2 inches long, protrudes from each depression.

Disease Cycle -- Spores from the gelatinous telial horns of the galls on red cedar are easily windborne. These infect the apple and fruit. Spore discharge begins about the pink stage of apple bloom and is usually completed in a few weeks. Following a few wet periods, the cedar galls die. Spots on the apple leaf can be seen about 10 days after infection. Visible fruit infections require a somewhat longer time.

The aecia on the underside of the apple leaf or on the fruit lesions produce spores that are again windblown. These may be carried back to the red cedar. After lodging in the leaf axils or in crevices on the cedar twigs, they germinate, infect the twig, and produce tiny galls the following spring. One year later, these galls are capable of producing gelatinous horns bearing spores that can infect the apple.

RUSTY SPOT

Hosts: Peach

The cause of rusty spot is uncertain, although many plant pathologists believe it to be the apple powdery mildew fungus.

Symptoms -- Rusty spot is recognized only on the fruit. The earliest symptoms are small, orange-tan areas. This symptom is due to a change in the color of the fuzz or hairs on the fruit. These first spots may become noticeable three to four weeks after shuck fall. The discolored area enlarges slowly, and the older discolored hairs begin disappearing, leaving a fuzzless, smooth, center spot surrounded by a non-uniform band of orange to tan hairs. Finally, the spots become quite spread out leaving brownish or reddish centers of hard, smooth skin that appear somewhat like a bruise from a limb rub. The highly red cultivars, or on the very red cheek areas of others, may show little evidence of the disorder once the peaches are washed and brushed after harvest. Less highly colored fruit often remain quite unattractive.

Disease Cycle -- Since the cause of rusty spot is not clear, no disease cycle can be given. New spots on the fruit may continue to appear up to the time of harvest. There does not seem to be any relationship between weather conditions and the number of diseased fruit.

SOFT ROT

Hosts: Apple and pear.

This common rot of stored apples and pears is caused by the fungus Penicillium expansum. Other names of the disease are blue mold, bin rot, and Penicillium rot. In addition to losses from the rot, sound fruit in the same container may absorb a moldy odor and flavor from the decaying fruit.

Symptoms -- Soft rot first appears as soft, watery spots on the outer surface of the fruit. These spots begin around injuries or lenticels. The decayed flesh is light brown, soft, and watery. Rotted fruit have a characteristic moldy odor and flavor. When the relative humidity is high, grayish-blue, cushion-like masses of spores may appear on the fruit surface - thus the name blue mold.

Disease Cycle -- The spores of the soft rot fungus are present most everywhere. They can survive long periods of unfavorable conditions. Bulk bins, field crates, pack-house lines, and storage rooms usually are contaminated. Injuries to the fruit, especially during picking and handling operations, are the primary points of entry. At ordinary temperatures, infected fruit can rot in two weeks or less.

Control -- Preventing injuries to the fruit during picking and handling and the rapid movement of harvested fruit into cold storage are essential to control of soft rot. Picking bins and boxes can be disinfected with fungicides or steam. Packing line equipment and storage rooms should be cleaned. Clean water should be maintained in water dumps and anti-scald solutions. Disinfectants or fungicides can be used in fruit dips and combined with wax applications.

SOOTY BLOTCH AND FLYSPECK

Hosts: Apple, crabapple and pear.

These are separate diseases but normally both are present on the same fruit. They cause only surface blemishes that detract from the appearance of the fruit. Sooty blotch will shorten the storage life of fruit due to increased water loss. Sooty blotch is caused by the fungus Gloeodes pomigena and flyspeck by Microthyriella rubi.

Symptoms and Disease Cycle -- Sooty blotch appears as sooty areas on the fruit surface. Their outline is not definite and the smudge can be removed by rubbing vigorously. The sooty areas are olive-green to black in color. Flyspeck looks like true flyspecks in groups of 10 to 50 or more.

Both fungi overwinter on the twigs of numerous wild hosts as well as apple and pear. The spores are windblown into and throughout the orchard. Cool temperatures, 65° F. is optimum, and rains or high humidity are ideal for infection. These diseases usually appear on fruit late in the season.

SOOTY MOLD

Hosts: Most common on pears, but can occur on all tree fruits and tree nuts.

Sooty mold fungi of the genus Capnodium cause an unsightly blackening over the surface of fruit and leaves. It occurs on many plants and most frequently on pear of the various tree fruits. These fungi live on honeydew excreted by some insects such as aphids, psylla, and white flies. When only a few insects are present on the host plants, and thus a small amount of honeydew, sooty mold appears in spots. When insect secretions are abundant, the surface of leaves and fruit may have nearly a continuous coating of the black, tissue-paper thin layer of sooty mold.

Control of sooty mold is directed against the insects producing honeydew. These will need to be determined before appropriate controls can be undertaken.

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DISEASES OF VEGETABLE CROPS

Accurate disease identification is the first step in planning an effective and efficient disease control program. Literally hundreds of different vegetable diseases exist. Although a vegetable grower will encounter only some of these during one season, he must be able to identify them and to distinguish significant and potentially serious diseases from less important diseases. The aim of this publication is to help vegetable growers identify important diseases.

Current recommendations for vegetable disease control are available in yearly revised pest control guides. Contact your local Extension office for these guides and for further assistance in diagnosing vegetable diseases.

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DISEASES OF BEANS

ROOT ROT is caused by several different soilborne fungi. Symptoms vary depending on organisms present and on environmental conditions. Root rot is a possible cause if plants wilt and die, if leaves turn yellow or drop off, if plants are stunted, or if pods are small with under-sized seeds. Characteristic symptoms caused by three major root rot fungi are described here.

Fusarium Dry Root Rot symptoms appear soon after seedlings emerge. The taproot is first slightly discolored, and gradually becomes brown with longitudinal cracks. Bottom roots are usually killed; new fibrous roots may form just above the discolored area and just below the soil surface. Continuous bean culture causes a buildup of the fungus in the soil. The fungus can survive in the absence of beans for about five years.

Rhizoctonia Root Rot is characterized by seed rot, a water-soaked stem rot near the soil line which results in wilt and death of new seedlings and slightly sunken reddish-brown longitudinal stem cankers near the soil line. If inner stem tissue is invaded, it becomes brick red.

Pythium Root Rot is characterized by colorless to dark-brown wet rot near the soil line. Young plants and sometimes older plants wilt and die.

BACTERIAL BLIGHTS on beans and lima beans are caused by several different bacteria, each causing a different disease.

Halo Blight on beans is characterized by numerous dead leaf spots with yellow halos. At high temperatures, halos may be absent, and entire leaves may be killed as the bacterium moves systemically in the plant. Under humid conditions, a creamy ooze is produced on pod spots.

Syringae Blight, more common on lima beans than on other beans, is characterized by small reddish-brown irregular spots on leaves. As spots enlarge, centers turn gray and drop out. Veins on lower leaf surfaces turn reddish-brown. Pod spots are more elongate than leaf spots.

Bacteria that cause these blights overwinter in the seed and in refuse from diseased plants left in fields; Syringae Blight also overwinters in several woody plants including lilac, cherry, pear, poplar, rose, and Forsythia. Bacteria is spread by splashing rain, by man, and on implements. Halo Blight is favored by cool wet weather whereas common blight is favored by warm weather.

MOSAIC SYMPTOMS include plant stunting; leaf mottling, puckering, and stunting; and sometimes pod distortion and stunting. Common Bean Mosaic and Yellow Bean Mosaic are two major bean virus diseases. Common Bean Mosaic is seedborne. Yellow Bean Mosaic is not seedborne but overwinters in clovers and gladiolus. Both viruses are spread from diseased plants to healthy plants by aphids, by leaves rubbing against each other, and by man working with healthy plants after working with diseased plants.

ANTHRACNOSE is characterized by black sunken lesions about 1/2 inch in diameter, and by salmon-colored ooze on pods, cotyledons, and stems. Pod spots are most conspicuous. Veins on lower leaf surfaces commonly turn black. The Anthracnose fungus overwinters in bean seed and in field soil or refuse from diseased plants. The fungus is spread by wind, rain, animals, man, or implements. Cool wet weather promotes disease development.

DOWNY MILDEW OF LIMA BEANS has as its most conspicuous symptom a white downy mold on pods. Infected pods shrivel, die, and turn black. Young shoots, flowers, and leaves are also affected. Leaf veins may become purplish and distorted; not much mold develops on leaves. The Downy Mildew fungus overwinters in diseased seed. In wet weather, the fungus grows, reproduces, and spreads rapidly by wind. A susceptible planting can be destroyed in a few days.

POD BLIGHT OF LIMA BEANS affects leaves and pods. Affected leaves have irregular brown patches with concentric circles of small black specks. Similar black specks develop on affected pods. Seeds in affected pods fail to form or are shriveled. The disease-causing fungus overwinters on seeds and in refuse from diseased plants. Sticky disease-causing spores are produced in the black speck-sized pustules on leaves and pods. Wet conditions promote spore production, spore spread, and disease development.

WHITE MOLD is characterized by a white cottony growth on pods and stems. Small, hard, black seed-like structures often form in the white mold growth. Rotted pods become wet and soft. Affected plants often die. The causal fungus overwinters in and near bean fields in refuse from diseased plants. Fungus spores are produced in wet spring weather and are carried to bean plants by wind. The disease gets its start on dying blossoms and on injured tissue. Disease development is promoted by moist conditions.

GRAY MOLD, chiefly a pod disease on beans, is characterized by a distinctive grayish powdery mold on bean pods. The causal fungus is present on most dead organic matter in fields. It grows and reproduces in moist conditions, and dry reproductive spores are spread by wind. Wet conditions promote disease development.

RUST is characterized by reddish dusty pustules, mostly on lower surfaces of leaves but also on pods. It is most prevalent on mature plants. The causal fungus overwinters on refuse from diseased plants. Dusty spores produced in leaf and pod pustules are spread by movement of man and implements in fields, and by wind.

POWDERY MILDEW begins as faint, discolored leaf spots from which a characteristic grayish-white talcum-like powdery growth spreads to all above-ground parts. Young leaves are dwarfed and curled and may turn yellow and drop. Pods are dwarfed and distorted. Powdery Mildew usually develops late in the season on mature plants.

DISEASES OF CRUCIFERS

WIRESTEM, BOTTOM ROT, AND HEAD ROT are caused by the same fungus that causes damping-off. Wire Stem is characterized by stems darkened and girdled near the soil line. Affected plants are weakened, produce small heads, and sometimes wilt and die. Bottom Rot develops on plants after they are transplanted to the field. Dark, slightly sunken spots develop on basal leaves near the soil. In moist conditions and in storage, rot spreads to adjacent leaves and causes a Head Rot. The causal fungus is present in all field soil. Disease is promoted by moist conditions.

DOWNY MILDEW, most serious in seedbeds, appears as small leaf spots which are first yellow and later turn brown with bluish-black, lace-like markings. In moist weather, a white downy mold develops on the underside of leaves. Vascular tissue becomes discolored. The causal fungus overwinters on seed, on crucifer weeds, and possibly in soil. Disease is promoted by cool, wet weather in the spring and in the fall. Downy Mildew can predispose plants to bacterial soft rot.

BLACK LEG symptoms are first seen as dark sunken cankers at the base of the stem. Stem cankers then enlarge and girdle stems, causing plants to wilt. Circular light-brown spots appear on leaves. A diagnostic feature of Black Leg is the presence of distinct tiny black specks within stem cankers and leaf spots.

The causal fungus overwinters on seed and for two to three years in refuse from diseased plants. The disease-causing fungus can be moved long distances on seed or on transplants; it can be spread within fields by dipping diseased and healthy plants in the same water, by working in fields containing diseased plants, and by splashing and running water.

BLACK ROT affects both young and mature plants. Affected seedlings turn yellow and die. On older plants, yellow sectors that turn brown form on leaf margins. Heads are dwarfed and one-sided, and lower leaves fall off. Vascular tissue turns black in veins running through dead leaf sectors. Vein discoloration then progresses to the base of the plant. Soft rot often develops on affected heads. The Black Rot bacterium overwinters on seed and for one to two years in refuse from diseased plants. Long-distance and local spread is the same as for Black leg.

CLUBROOT causes wilting and yellowing of above ground parts. The diagnostic symptom is the presence of greatly enlarged roots. The causal fungus is soilborne and persists for at least seven years. Soil pH below 7.2 favors disease development.

FUSARIUM YELLOWS is most severe on cabbage but also affects other cole crops. Affected plants have a sickly, yellow, dwarfed appearance. Affected leaves frequently have purple edges and brown bases. Lower leaves drop one by one. Vascular tissue in veins turns dark in affected sides of leaves and plants. This discoloration develops from the base of the plant toward leaf margins.

The causal fungus is soilborne and can persist for many years. Disease development is promoted by high soil temperature.

ALTERNARIA LEAF SPOT develops on lower leaves as distinct spots with concentric dusty black circles. Black dusty fungus growth develops on spots during moist periods. During storage, spots expand; soft rot may get started in dead leaf spots. The causal fungus overwinters in seed and in refuse from diseased plants. Wet conditions promote disease development.

EDEMA appears as small brownish-gray wart-like growths on the leaf surface. The wart-like growths are thought to be initiated by leaf injury caused by sand or insects. It usually develops during cool nights following warm muggy days. Under these conditions, water uptake is faster than water loss; consequently, the leaf epidermis breaks, and expanding leaf cells are exposed and become corky.

DISEASES OF CUCURBITS

ALTERNARIA LEAF SPOT occurs primarily on muskmelons but also on cucumbers and other cucurbits. Leaf spots are first small, circular, and water-soaked; they then expand up to 1/2 inch in diameter with concentric circles within the spots. Spots coalesce causing defoliation that starts with crown leaves. This disease-causing fungus overwinters on and in seed, and in refuse from diseased plants. Disease-causing spores are spread by wind, by running and splashing water, on field workers, and by implements. Weak and aging plants are more susceptible than vigorous plants.

ANTHRACNOSE affects cucumbers, muskmelons, and watermelons. Muskmelon and cucumber leaf spots begin as yellowish or water-soaked areas that enlarge rapidly, turn brown, and shatter to form a ragged hole within the spot. Leaf spots on watermelons turn black. Elongated dark spots with light centers often develop on petioles and stems and can cause death of tissue beyond these spots. Young fruit may be killed, but large fruit usually develops depressed dark-bordered cankers with flesh-colored ooze in the center. The fungus overwinters in seed and in refuse from diseased plants, and it spreads in splashing water. Humid weather and frequent rains promote disease development and spread.

ANGULAR LEAF SPOT OF CUCUMBER is characterized by conspicuous leaf symptoms; stem and fruit symptoms occur but are less conspicuous. Leaf spots are angular and irregular in shape and size. Spots are first water soaked, later turn brown, and then drop out leaving ragged holes. The bacterium causing this disease overwinters on seed and persists on crop refuse from diseased plants. Splashing rain spreads the bacterium in fields.

POWDERY MILDEW affects cucumber, muskmelon, pumpkin, and squash. It is caused by a fungus that appears as a white powdery growth on leaves. Crown leaves are affected first and may wither and die. The disease-causing fungus can be introduced on greenhouse-grown plants or from southern areas by wind. Disease development is favored by high temperatures.

DOWNY MILDEW on cucumbers and muskmelons overwinters in the south and develops in northern areas when environment favors early northward spread. Irregularly shaped yellowish to brown spots appear on upper sides of leaves, usually at the center of plants. Under moist conditions, a purplish mildew develops on the underside of leaf spots. Leaves are killed as spots increase in size. Spread is rapid from the crown toward new growth. Moist conditions favor disease development.

SCAB affects muskmelons and susceptible cucumber varieties. Dry, corky spots, up to 1/2 inch in diameter, develop on cucumber and green muskmelon fruit. Under moist conditions, a dark olive-green, velvety growth covers the spot; this distinguishes scab from angular leaf spot on cucumber fruit. Spots also develop on young terminal stem growth and on petioles. When spots girdle young stems and petioles, growth beyond the spot is killed. Irregular leaf areas are killed on very young leaves. The disease-causing fungus overwinters on seed and in refuse from diseased plants. Disease development is promoted by foggy, cool weather and cool night temperatures.

CUCUMBER MOSAIC VIRUS (CMV) is important on muskmelons, summer squash, and cucumbers. CMV also affects other cucurbits and other vegetables. On affected plants, vines are stunted; new leaves are dwarfed, mottled, and sometimes distorted; leaves sometimes wilt and die. Old expanded leaves on muskmelons and cucumbers often slowly turn yellow and dry up, resulting in a slow decline of affected plants. CMV overwinters in many biennial and perennial flowers and weeds. CMV is carried to new plantings by aphids and is spread within plantings by aphids and by man when he works in the plantings.

BACTERIAL WILT is characterized initially by wilting and drying of individual leaves which may exhibit cucumber beetle chewing injury. Later, most leaves on one or more laterals or on entire plants wilt. Wilted parts may recover at night, but they wilt on successive sunny days, and finally die. A diagnostic test for Bacterial Wilt is to cut a wilted stem near the crown, squeeze sap from the newly cut stem, and watch for a white exudate from the vascular bundles. If a clean knife is touched to and then slowly withdrawn from the newly cut surface of the stem, a white ooze may string out in a fine thread between the knife and stem. Presence of the white exudate and stringing out of the ooze is a positive test for Bacterial Wilt. Positive test results appear to be easier to obtain for cucumber and for some squash than for muskmelons. The disease is more prevalent on cucumber and muskmelon than on pumpkin and squash. The wilt-causing bacterium overwinters in striped and 12-spotted cucumber beetles, and is carried to plants when beetles feed.

FUSARIUM WILT OF MUSKMELONS is characterized by stunting, yellowing, wilting, and dying of vines. A streak, at first water-soaked, later turning yellow to tan, and finally dark brown, often appears at the soil line on one side of the vine; this symptom is diagnostic. The disease-causing fungus survives in soil for many years. High soil temperature favors fungus growth.

FUSARIUM WILT OF WATERMELONS is characterized by seedling damping-off, and by stunting, wilting, and death of established plants. Vascular tissue may be discolored. White mold may develop on dead vines. The disease-causing fungus is soilborne and can persist in soil for many years.

LATE COLLAPSE OF MUSKMELONS is characterized by a sudden collapse of plants. Collapse occurs late in the season on bright sunny days following heavy rains and cold nights that cause a significant drop in soil temperature. Temperatures of 50° F. at the four-inch soil depth appear to trigger the collapse. Collapse can be severe after cool wet summers because (a) the critical soil temperature can be reached relatively easily, and (b) cool wet weather favors root rotting, an additional stress that promotes wilting.

CHOANEOPHORA WET-ROT is a summer squash fruit rot affecting wilted blossoms and spreading to attached fruit. Invaded fruits rot rapidly and are covered with fungus growth. The fungus growth resembles small black-headed pins stuck into the fruit. The disease-causing fungus is spread by insects, wind, and splashing water. Disease development is promoted by high moisture conditions.

FUSARIUM FRUIT ROT ON MUSKMELONS, caused by a soilborne fungus, is characterized by fruit spots of 1/2 inch to 1 inch in diameter on ripe muskmelons. The rot is dry and usually has 1/2-inch deep, spongy, white (sometimes rose-colored) tissue that can be easily removed from unaffected tissue. In wet conditions and during storage, a white mold develops on the surface of the fruit spot.

BLACK ROT (FRUIT ROT) AND GUMMY STEM BLIGHT are caused by the same fungus. Different symptoms develop on different cucurbits. Winter squash, pumpkins, and gourds are affected most by black rot. Black Rot starts as irregular circular fruit spots that are first faded-green or yellow, later gray to brown, and finally black. The fruit rot penetrates through the rind and causes a dry rot in the flesh below. Other rot organisms may follow and cause a wet rot that affects the entire fruit.

Muskmelons, cucumbers, and watermelons are affected most by Gummy Stem Blight, which begins as pale brown or gray spots on leaves, petioles, and stems. Stem spots usually start at the nodes and elongate into stem streaks. Leaves on affected vines turn yellow and die, and occasionally entire plants are killed. Tiny, black, pimple-like structures develop on fruit, stem, and leaf spots. The disease-causing fungus overwinters in seed and in refuse from diseased plants.

DISEASES OF PEAS

PEA ROOT ROTS are caused by several different soil fungi. These fungi cause conspicuously discolored and rotted areas on the main root and at the base of the stem. It is difficult to distinguish between root rots caused by different fungi. Often several different root rots are present on the same plant. Specific symptoms characteristic for some root rots are noted below. Diseases are named for the organism that causes the rot.

Aphanomyces Root Rot is characterized by water-soaking, softening, and slight discoloration of the tap root and lower stems. Often the outer root tissue can be readily slipped from the central woody root tissue.

Fusarium Root Rot symptoms appear on the stem just above the region of seed attachment. Affected stem areas turn dark reddish-brown. Internal woody stem tissue sometimes turns brick red.

Rhizoctonia Root Rot symptoms usually begin on the underground stem and on roots. Affected areas are brown to reddish-brown, sunken, and eroded.

Ascochyta Root Rot symptoms begin as purplish streaks above and below ground on the stem and particularly at nodes. Streaks enlarge into dark brownish-purple areas which may girdle the stem and extend several inches above ground.

These root rot fungi persist in soil and in refuse from diseased plants. In addition, Ascochyta is seedborne. Excessive soil moisture, whether from heavy rainfall or from poor drainage, favors root rots. Root rot is more likely to develop on weak, slowly growing plants than on vigorous, more rapidly growing plants.

PEA BLIGHTS of most importance are Ascochyta Blight and Bacterial Blight.

Ascochyta Blight is caused by any of three related fungi. Symptoms develop on stems, roots, leaves, and pods. Black to purplish streaks develop on stems. Streaks are most conspicuous at the nodes and enlarge into brown to purplish irregular-shaped areas from the roots to about ten inches up the stem. Root rot symptoms are described in the Ascochyta root rot section. Leaf spots are gray to purplish and may be very small and irregular, or large and circular. Concentric rings sometimes form in leaf spots. Severely affected leaves may shrivel and die. Pod spots are gray to purplish, lack concentric rings, and are sunken. The blight-causing fungi are seedborne. Abundant rainfall favors disease spread and development.

Bacterial Blight affects all above-ground plant parts. Seedlings from diseased seed may be killed. On older plants, water-soaked spots develop on pods, stems, and leaves. In wet weather, spots enlarge, and a white to cream-colored slimy ooze may collect on the spot surface. In dry weather, leaf spots dry up, turn brown, and become papery. The causal bacterium overwinters in seed and likely is introduced yearly through infected seeds; it probably does not overwinter in refuse.

FUSARIUM WILT AND NEAR WILT are two major pea wilts. Symptoms and controls for these two wilts differ although they are caused by related fungi.

Fusarium wilt initial symptoms are yellowing of lower leaves and stunting of the entire plant. Leaflet margins curl down and inward. The stem may be slightly swollen and brittle near the soil line. The internal woody stem tissue is often discolored lemon to orange-brown. Externally, the root system appears healthy; however, secondary root rots are likely on plants wilted for long periods. Eventually, wilted plants may die.

Near Wilt symptoms are similar to Fusarium Wilt symptoms. However, plants infected with Near Wilt die more slowly than those infected with Fusarium Wilt. Also, internal woody stem tissue is usually brick red in Near Wilt plants; this discoloration extends through the entire plant.

Fungi that cause Fusarium Wilt and Near Wilt can be introduced with the seed. Once present, these fungi persist indefinitely in soil.

PEA VIRUSES include these four important diseases, each caused by a different virus and each showing a different set of symptoms.

Pea Enation Mosaic virus causes yellowish areas on leaves and blister-like ridges (enations) on undersides of leaves; on pods, it causes pod distortion, and suture splitting.

Bean Yellow Mosaic virus (BV-2) causes green and yellow-green mottle or mosaic patterns, and promotes growth from axillary buds.

Pea Stunt, caused by red clover vein mosaic virus, is characterized by light-colored veins, terminal rosettes, stunting, and poor pod set.

Pea Streak, caused by a combination of the pea enation and pea stunt viruses, is characterized by purplish-brown flattened pods, purplish-brown streaks on stems, death of veins, yellowing on some leaves, and eventual wilting and death of terminal growth.

Viruses that cause these diseases overwinter in some plants belonging to the pea family (clovers, vetches, alfalfa). Aphids pick up viruses from these plants and transmit the viruses to peas.

DISEASES OF POTATOES

BLACK LEG symptoms appear at the stem end of tubers as yellowish tissue which eventually becomes black. The rot may hollow out the entire tuber, and may be slimy, watery, or dry, depending on soil conditions. When infected seed pieces decay, the bacteria may enter new shoots, causing the stems to become soft and black. High moisture conditions and warm weather favor disease development; in warm and dry weather, infection will not cause plant death, but will retard growth and reduce yield. The bacteria, which overwinter in seed tubers, soil, or plant debris, can enter the plant only through wounds caused by insects, bruising, sunscald, or pathogenic fungi.

RING ROT first appears as a light-yellow to light-brown discoloration of the vascular ring at the stem end. As the disease progresses, the entire vascular ring rots with cavities extending to the center of the tuber. The surface of tubers may be cracked and depressed.

Disease-causing bacteria persist in stored potatoes, on equipment, in plant debris, and in cull tubers in the field. In storage, the bacteria can infect seed.

COMMON SCAB appears as darker-than-normal, corky, rough areas raised above or sunken below the healthy skin. The disease-causing fungus persists in the soil and on infected seed tubers. Dry soils and temperatures between 65 to 70° F. favor scab development. Soil-insect larvae are frequent invaders of the lesions, and thus make the disease more severe.

LEAK fungus invades seed pieces, making them watery, but not slimy. Seed planted in warm, moist soil becomes yellowish to brown, and then black. Water from affected tubers is most often clear, but may be yellowish or brown. Tubers can be infected through wounds, bruises, or insect injuries.

If infected tubers are placed in storage, the disease is not evident for two to four weeks, at which time they become watery and soft. The central portion of the tuber is dark brown to black, with a sharp line separating healthy from rotted tissue. If the tuber is squeezed, a clear, yellowish water will come out.

Late-planted cut potato seed is most vulnerable to infection, especially if harvested when temperatures are above normal and soil is moist.

PINK ROT is caused by a soil-inhabiting fungus that attacks tubers. Internal symptoms begin at the stem end, first as rubbery tissue from which water will exude under pressure. The tissue turns pink as the decay progresses. Basal stem decay and top wilting may occur.

High soil moisture and temperatures in the mid-70s are optimum for tuber rot development.

At high temperatures, the rot is usually jelly-like; at low temperatures, it is usually dry and may extend far into the tuber.

Fungus infection requires open wounds, warm temperatures, and moisture.

RHIZOCTONIA causes different symptoms on tubers and on shoots, stolons, and roots. On tubers, black scurf develops. On the shoot, stolon, and roots, cankers develop.

Black scurf is common and usually harmless. It detracts from the appearance of the potato. Black scurf consists of scattered black dots which range from pinhead size to 1/4 inch in diameter. Any spots (fungal bodies) on seed will germinate when the seed is planted; these fungal bodies will infect shoots, roots, and stolons.

When Rhizoctonia attacks shoots, roots, and stolons, it causes sharply delimited, sunken brown lesions. The lesions may extend to several inches long, may be on one side, or may completely girdle the affected portion. The lesions damage the vascular tissue and cortex, and can kill the affected portion if they develop near the growing tips. When shoots and stolons are attacked less severely or late in the growing season, the plant is not killed. However, movement of nutrients from leaves to tubers is hampered, and the leaves become cupped, hard, and discolored, and aerial tubers develop.

MOSAICS are virus diseases which do not affect the eating quality of potatoes. However, they reduce the size and number of tubers produced.

Mild mosaic appears as a yellowish or light-colored mottling of the leaf. The mottled areas are variable in size and are not limited by the veins. Diseased plants droop and die prematurely. Mild mosaic is usually more distinct during the early part of the season.

Rugose mosaic is readily distinguished from mild mosaic by the smaller and more numerous mottled areas distributed closer to the main veins. On the undersides of lower leaves, thin black necrotic areas often develop on veins. The leaves become brittle and then drop; the plant dies prematurely.

Mosaic diseases overwinter in stored tubers, and are spread from contaminated plants to healthy plants by insects, persons, or machines.

LEAF ROLL virus disease is easier to detect on tubers growing from infected seed than on tubers infected while they are growing. Affected leaflets are lighter than normal and may show a red tint. The leaves curl upward, and assume a rigid, leathery texture. As new leaves form, they become infected; this decreases the number and size of the tubers.

In tubers, the disease causes a conspicuous netted pattern of necrotic tissue.

Aphids spread the disease in the field, and infected tubers carry it in storage. The storage temperature most favorable for disease development and spread is between 45 and 50° F.

TUBER LATE BLIGHT first appears as small, irregular, pink to brick-red areas just beneath the skin. As the disease progresses, these areas enlarge and become depressed. Tubers blighted before harvest will usually decay rapidly, and are open to secondary invasion by soft rot bacteria.

If tubers are blighted when harvested and are stored at temperatures of 50 to 60° F., the disease-causing fungus will spread and cause more disease in storage. Tubers become dry, firm, and leathery, and can be infected by soft rot.

The disease-causing fungus is a water mold which requires high humidity or free water for reproduction and infection. Tuber blight is most prevalent and severe in heavy moist soils, but even loose soils--if they remain wet--will allow disease development. The fungus overwinters on blighted tubers.

VERTICILLIUM WILT symptoms appear first on leaves at flowering time. The leaves become dull green with irregular yellow areas, and eventually become brown and withered. Leaf yellowing begins on the lowest leaves and progresses upward until the entire stalk is dead. The vascular ring in affected tubers is dark brown at the stem end and becomes progressively lighter through the tuber.

The disease-causing fungus may be in the seed or in the soil from previously infected potato-related crops. The fungus spreads from the seed piece into the sprout or from the soil into the roots or sprout.

Cultural practices or environmental conditions which hasten maturity will cause earlier and more severe wilt symptoms. The disease causes serious yield losses in dry soils with low fertility, poor weed control, and heavy insect infestations.

EARLY BLIGHT can affect both plants and tubers. On leaves, small, oval or angular dark-brown or black spots are surrounded by a narrow yellowish zone. Lowest leaves dry up first as the disease progresses upward on the plant.

On tubers, the fungus causes sunken lesions slightly darker than the skin, with underlying tissue showing a corky dry rot. The margin around the lesion is well-defined and sometimes slightly raised.

The disease-causing fungus is windborne.

SILVER SCURF is a fungus disease confined to tubers. It begins as circular or irregular brown lesions which appear silvery when moistened. As the color gets darker, the skin sloughs off and shrivels. The skin color on red varieties may become brownish. Tubers become susceptible as they approach maturity. High humidity is essential for disease development.

FUSARIUM DRY ROT infects seed potatoes and stored tubers only through wounds and bruises caused during or after harvest. Symptoms vary greatly depending on the species of Fusarium fungus and the environmental conditions. Generally, symptoms appear as brown or black sunken, shriveled, or broken areas which may have a white, yellow, or reddish mold growth on or in tubers.

DISEASES OF SWEET CORN

STEWART'S BACTERIAL WILT is more severe on young plants than on older plants. Symptoms appear first on leaves. Pale green to yellow streaks with wavy margins may extend the length of the leaf. These streaks usually change from pale green to yellow or brown. Brown discoloration and cavities may sometimes form in the center of the stem near the soil line. Early-infected plants may die; late-infected plants may be stunted or merely have streaked leaves.

The disease-causing bacterium overwinters in flea beetles and is spread to corn when flea beetles feed on corn plants. Warm winters favor overwintering of flea beetles and usually precede seasons when Stewart's bacterial wilt is prevalent. Flea beetles can be expected if the average monthly temperatures of December, January, and February--when added--total more than 90. For example, if the mean temperature of December is 34° F., that of January is 29° F., and that of February is 30° F., the presence of Stewart's Bacterial Wilt is a strong possibility for the next growing season.

LEAF SPOTS found on sweet corn are Northern Corn Leaf Blight (NCLB), Southern Corn Leaf Blight (SCLB), Yellow Leaf Blight (YLB), and Anthracnose. Leaf spot size and color help distinguish different diseases from each other; also specific environmental conditions favor development of each disease. For convenience of comparison, specific information is summarized in the following table.

<u>Disease</u>	<u>Spot Size (Inches)</u>	<u>Spot Color</u>	<u>Conditions Favoring Disease</u>
NCLB	1/2 x 1 to 6	Grayish-green to tan	65 to 77°F., dew
SCLB	1/4 to 1/2 x 1/2 to 1 1/2	Tan with yellowish to reddish-brown border	68 to 90°F., damp
Anthracnose	1/8 to 1/2 x 1/2	Brown with reddish- brown border	High temperatures, drying leaves
YLB	1/10 x 1/2	Yellow-cream to tan; sometimes with yellow halo	Cool, wet

MAIZE DWARF MOSAIC (MDM) is characterized by distinct symptoms that appear on youngest leaves before tasseling. Affected plants have a fine stippling of dark green streaks on chlorotic young leaves. Upper internodes are shortened. Symptoms on older plants include yellowed leaves, plant stunting, excessive tillering, presence of multiple ear shoots, and poor seed set. MDM is caused by a virus that overwinters in grasses. Two virus strains (A and B) exist. Johnsongrass is likely a major overwintering host for strain A; strain B does not overwinter in this host. At least 12 kinds of aphids transmit the virus from infected grasses to corn.

SMUT is characterized by presence of large, fleshy, irregular galls on leaves, stems, ears, and tassels. Immature galls are white and spongy; mature galls turn brown and contain powdery dark spores. Smut is caused by a fungus that overwinters in contaminated soil. Smut development is favored by dry conditions and by temperatures between 79 and 94° F. Disease development is promoted by plant injury caused by hail, cultivation, and insects.

DISEASES OF TOMATOES

Tomato diseases are grouped into symptom categories to help with diagnosis. Categories are: Wilts, leaf spots and blights, fruit spots and rots, internal browning and graywall, and viruses and herbicides.

TOMATO WILTS are caused by several different agents. Four common wilts are Verticillium Wilt, Fusarium Wilt, Bacterial Wilt, and Walnut Wilt. Information on varietal resistance, range of crops affected, proximity to walnut trees, soil temperature, and past cropping history help determine which wilt is present. Usually a laboratory isolation is needed to verify the cause. Bacterial Canker and Leaf Roll, two other disorders often mistaken for wilts, are also discussed here.

Verticillium Wilt affects many plants and is prevalent on tomatoes, potatoes, eggplants, peppers, strawberries, and raspberries. It is characterized by yellowing, drying, and premature dropping of leaves. Affected plants are usually stunted but not killed. Vascular tissue may be discolored. The disease is caused by a soilborne fungus that can persist in soil for many years. Verticillium Wilt is prevalent in cool environments.

Fusarium Wilt affects only tomatoes. It is characterized by plant stunting and leaf yellowing, wilting, and dying. Leaf symptoms appear first on oldest leaves at the base of the plant but later develop on successively younger leaves toward the plant top. Sometimes symptoms appear on plants only after they are dead. Vascular tissue turns brown in diseased plants. Fusarium Wilt is caused by a soilborne fungus that can persist in soil for many years. Many tomato varieties are resistant to a common race (race 1) of this fungus; however, these "resistant" varieties may not be resistant to a recently detected race (race 2). Fusarium Wilt is restricted by cool climate.

Bacterial Wilt affects several plants including tomatoes, potatoes, eggplants, and peppers. It is characterized by sudden plant wilting without leaf yellowing. Stem centers (pith) become water soaked, later turn brown, and sometimes become hollow. Woody stem (vascular) tissue turns brown, and adventitious roots may be prevalent. The disease-causing bacterium does not overwinter in northern soils and usually is a problem only after it is introduced on transplants.

Walnut Wilt affects several plants when they are growing within the root zone of walnut and butternut trees. The wilt is particularly prevalent on tomatoes. Woody stem (vascular) tissue turns brown in affected plants, and plants soon wilt and die. A toxin from both living and dead tree roots causes the problem.

Bacterial Canker causes wilting, rolling, and bronzing of tip leaves. On older plants, foliage dies from the margin and finally kills the plant. Yellowish-white streaks may appear on petioles and stems and may develop into longitudinal cankers. Cavities may develop within stems. Spots on fruits are first small and whitish but soon develop raised brown centers surrounded by a white halo which later turns brown. The disease-causing bacterium may survive for one year in refuse from diseased plants. It is also seedborne and therefore can get started and be spread on transplants.

Leaf Roll is characterized by upward curling of leaflets on older leaves. Leaf roll has been associated with severe pruning and with high soil moisture following heavy rains.

TOMATO LEAF SPOTS AND BLIGHTS are caused by several different agents. Early Blight, Late Blight, Septoria Leaf Spot, and Bacterial Spot frequently occur.

Early Blight can affect seedlings but is generally observed on older plants. On seedlings, dark spots develop on cotyledon leaves, stems, and true leaves. Spotted cotyledon leaves may be killed, and spotted stems may be girdled. On established plants, dark brown spots with dark concentric rings develop first on oldest leaves. Spotted leaves may die prematurely resulting in substantial early defoliation, fruit sunscald, and poor fruit color. (See the section about tomato fruit rots for fruit symptoms.) The disease-causing fungus overwinters in crop refuse from diseased plants and can persist in refuse at least one year. The fungus is also seedborne and can be introduced on seed and on transplants. Disease is promoted by cool wet conditions and is severe on plants of poor vigor.

Late Blight affects both tomatoes and potatoes. On tomatoes, foliage and fruit are affected. Irregular, greasy, gray areas develop on leaves. During moist conditions, these areas expand rapidly, and a white downy mold growth appears at the margin of the affected area on the lower surface of leaves. If the white fungus growth is not observed, leaves with suspicious spots can be put into a polyethylene bag containing a wet sponge to supply moisture, and held for one day to promote appearance of this diagnostic sign. Fruit symptoms are described with tomato fruit rots. The disease-causing fungus overwinters in southern frost-free areas, on winter-grown tomatoes and potatoes, and in northern areas in potato cull piles and potato seed. It may be introduced to tomato fields on southern-grown transplants or may be windborne from diseased potatoes and tomato plants in nearby fields. Disease development is promoted by cool, wet conditions.

Septoria Leaf Spot is characterized by small gray leaf spots with dark borders. Black pin-point size specks may be found within the spot. The disease-causing fungus survives in refuse from diseased plants and on or in seed. Fungus growth and spread, and subsequent disease development, are favored by wet weather.

Bacterial Spot affects tomatoes and peppers. Symptoms include dark greasy spots on leaves and stems. Fruit symptoms are more diagnostic and are described in the section on tomato fruit rots. The disease-causing bacterium may survive for one year in refuse from diseased plants. It is seedborne and therefore can get started on and can be spread on transplants. Wet weather promotes bacteria growth; splashing rain favors spread; and driving rain assists entrance of bacteria into plants.

TOMATO FRUIT SPOTS AND ROTS frequently observed are Anthracnose, Early Blight, Late Blight, Blossom-end Rot, Bacterial Spot, and Bacterial Speck.

Anthracnose, a frequent rot on ripe fruit, first appears as small, circular, indented spots. Spots increase in size, and the central portion darkens. Anthracnose spots on a single fruit often coalesce. Spotted fruits may rot completely, often as a result of attack by secondary fungi. The anthracnose fungus overwinters in refuse from diseased plants and also on and in seed. The fungus can become established on Early Blight leaf spots

and on other dead areas on leaves. Fruit spots are started by the fungus being splashed to the fruit either from the soil or from plant parts. Green fruit can become infected, although spots do not appear until fruit ripens. Disease is prevalent on fruit that is overripe and in direct contact with the soil. Wet weather promotes disease development.

Early Blight, more important on foliage than on fruit, also causes rot on both green and ripe fruit. Spots usually begin at the stem end and develop into a black, leathery, sunken area, often with dark concentric rings. Leaf symptoms and important disease cycle information are presented with the discussion of tomato leaf spots and blights.

Late Blight, although not common, can be devastating on both foliage and fruit. On green fruit, gray-green water-soaked spots enlarge to indefinite size and shape. Affected areas become dark brown, firm, wrinkled, and have a fairly definite margin. See the section on tomato leaf spots and blights for leaf symptoms and disease cycle information.

Blossom-end Rot is characterized by a large, dry, brown to black, often depressed, leathery area at the blossom end of fruit. The rot is caused by calcium deficiency in developing fruit. This deficiency usually results from excessive nitrogen fertilization, rapid plant growth, heavy rainfall, or drought.

Bacterial Spot is characterized by a distinct fruit spot. Small, dark, raised spots, sometimes surrounded by a water-soaked margin, appear on green fruit. Spots enlarge to 1/8 to 1/4 inch in diameter and become brown and scabby. Leaf symptoms and disease cycle information are presented in the section about tomato leaf spots and blights.

Bacterial Speck affects only tomatoes. Small black spots appear on leaves, stems, fruit stems, and fruit. Fruit spots are most characteristic. They appear only on young green fruit and consist of superficial, slightly raised, 1/16-inch dark specks. Tissue around fruit specks remains green longer than the rest of ripening fruit. The disease-causing bacterium is thought to overwinter on seed, and possibly for short periods of time in refuse from diseased plants, or in soil. The bacterium can be introduced into fields on southern-grown transplants. Wet weather promotes bacteria growth; splashing rain and machinery movement through fields assist spread and entrance of bacteria into plants.

INTERNAL BROWNING AND GRAYWALL (BLOTCHY RIPENING) are thought to be two different disorders with similar symptoms. Affected green fruit has grayish-brown blotches on the shoulders; internal wall tissue, particularly vascular tissue, is brownish. As fruit ripens, discolored blotches are yellowish on an otherwise ripe fruit.

Internal Browning is caused by tobacco mosaic virus. Symptoms will develop on fruit approaching maturity if plants are infected at this late stage of fruit development. Fruit that develops on earlier infected plants is less likely to develop Internal Browning symptoms.

Graywall (Blotchy Ripening) has been associated with specific environmental factors and possibly bacteria. Graywall is promoted by low light intensity (a condition prevalent among dense vines), low temperature, high soil moisture, excessive soil compaction, high nitrogen levels, and low potassium levels.

VIRUSES AND HERBICIDES often cause leaf deformation that is most severe on new growth. Tobacco Mosaic, Cucumber Mosaic, and 2,4-D injury are three common causes of these symptoms.

Tobacco Mosaic is caused by a virus that affects tomatoes, eggplants, peppers, and related plants. Symptoms on tomato foliage include light- and dark-green mottling with curling and slight malformation of leaflets. Sometimes green fruit is also mottled. Affected plants may be stunted. The virus is very persistent, infectious, and easily spread by merely brushing against plants. The virus is not spread by aphids.

Cucumber Mosaic is caused by a virus that affects hundreds of unrelated plants. Infected tomato plants are stunted, have short internodes, and may have extremely distorted and malformed leaves. Very narrow leaves are referred to as the "shoestring" symptom. Cucumber Mosaic virus is not persistent in refuse, is more difficult to transmit by rubbing than Tobacco Mosaic virus, and is usually spread by aphids. Since aphids are responsible for most spread, infected plants are usually widely separated within a field.

2,4-D herbicide injury occurs frequently in greenhouses and fields. Symptoms include downward bending of leaves and of growing points. New leaves do not expand fully; they twist at the margin and are narrow and elongated with abnormally pointed tips. Leaf veins are prominent, light colored, and appear parallel. Plants exposed to small amounts of herbicide should outgrow the injury, whereas virus infected plants will not. Source of herbicide injury is often not readily apparent. Possible sources include (a) direct herbicide application and (b) soil, equipment, tools, containers, clothing, and gloves contaminated from a previous herbicide use.

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DISEASES OF GRAPES

The six most common diseases of grapes in Pennsylvania are black rot, downy mildew, powdery mildew, dead arm, crown gall, and gray mold. Other diseases that may occur are anthracnose and those caused by nematodes and viruses. Grape disease control program needs vary with varieties, geographical locations, and weather conditions.

ANTHRACNOSE

This disease is a minor problem on the common commercial varieties grown in Pennsylvania. It is seldom seen on Concord.

Anthracnose, caused by the fungus Elsinoe ampelina, is also known as bird's-eye rot from its appearance on the fruit. The disease appears first as dark red spots on the berry. Later, these spots are circular, sunken, ashy-gray and in late stages these spots are surrounded by a dark margin which gives it the "bird's-eye rot" appearance. The spots vary in size from 1/4 inch in diameter to about half the fruit.

The fungus also attacks shoots, tendrils, petioles, leaf veins, and fruit stems. Numerous spots sometimes occur on the young shoots. These spots may unite and girdle the stem, causing death of the tips. Spots on petioles and leaves cause them to curl or become distorted.

BLACK ROT

This is the most common and the most destructive disease of grapes in all areas of Pennsylvania except along Lake Erie. Black rot is caused by a fungus, Guignardia bidwellii, which attacks the leaves, fruit, young canes, tendrils, and petioles.

The symptoms of the disease can be seen on leaves about ten days after infection as brownish circular spots. Tiny black dots, known as pycnidia, eventually appear in these spots. The spores formed in the pycnidia ooze out during rainy weather and are splashed or blown to other parts of the vine. A prolonged wet period is necessary for severe infection. Fruit infection can occur shortly after the calyx falls, but most occurs when the fruit is half to nearly full size. The rot first appears on the fruit as a light circular spot about eight days after infection and the entire berry becomes discolored within two to three days. Black specks (pycnidia) form on the infected berries soon after the rot appears. The affected berries turn into hard, black mummies within a week or ten days and usually remain attached to the stems. Shattering of the berries may occur, depending upon the variety, but some mummied berries usually remain attached all winter. In the spring, spores formed by the fungus on berries, leaves or shoots are ejected and start new infections on the new leaves, shoots, and other susceptible parts. The first infections usually occur when the new shoots are six inches or longer.

CROWN GALL

This bacterial disease is caused by Agrobacterium tumefaciens and is common on many other fruits, ornamentals, and trees. More or less spherical reddish-brown galls are formed on the roots. These can become as large as walnuts. They may be seen also on the stems above the ground as hard brown to black galls. When the galls or swellings caused by this disease are numerous the growth of the vine is affected.

Soil fumigation, especially in nurseries, may be practiced as one means of control.

DEAD ARM

This disease, caused by the fungus Phomopsis viticola, kills the shoots and branches (or arms). It also attacks fruit and leaves.

Most new-shoot infections occur before the shoots are 12 inches long. All parts of the shoots are subject to infection. New lesions are dark and eventually become elongated. Fruit infection, which is rare, causes a rot quite similar to black rot in appearance. The rotted tissue is not as dark as black rot and the pycnidia are larger, but less numerous. Spores produced in pycnidia on the canes, arms or trunks, and on mummied berries, are dispersed early in the season and infections are usually limited to the first six or seven nodes.

Trunk-infection symptoms are the most easily detected in June. The shoots from infected arms and trunks that were not killed during the winter are very much stunted. The leaves are small, crinkled, and yellow -- especially at the margins. They cup upward or downward and the margins are ragged and irregular. The fungus enters the trunk and supporting arms through pruning stubs or breaks caused by winter injury. The fungus invades all portions of the wood. A cross section of the trunk may reveal a V-shaped section of darkened wood that extends toward the ground line. Affected shoots occur on either or both sides of the vine, depending on the location of the infected trunk tissue. Affected canes may die at any time during the year, but most die during the winter months. If the disease girdles the trunk, all upper portions die.

DOWNY MILDEW

The fungus, Plasmopora viticola, attacks the fruit, foliage, shoots, and their tendrils during their immature stage. It overwinters in old infected leaves on the ground. Spores formed in these leaves are blown to leaves, shoots, and blossom clusters during cool, moist weather in the spring and early summer.

The first symptom of the disease on the leaves are light yellow or greenish-yellow spots on the upper sides of the leaves. A delicate, white-to-grayish growth of the fungus soon appears on the under surface of these spots. The areas of the leaf invaded by the fungus are killed and turn brown. When the disease is severe, considerable leaf fall results. Young shoots and tendrils are shortened, thickened, and twisted by the disease. Affected areas become covered with the whitish fungus.

Early fruit infection, which occurs when the berries are about the size of peas, usually results in the berry becoming soft, shriveling, and falling. Older berries of some varieties turn a brown or reddish color. This fruit remains hard and may be covered with the downy white growth of the fungus. At some stages, it may be mistaken for powdery mildew.

POWDERY MILDEW

The fungus, Uncinula necator, is found mostly on the leaves and fruit stems, but it will also infect green fruit in some seasons. Affected berries have a dull, darkened appearance and are usually covered with the light powdery growth of the fungus. In some varieties new fruit infection will cease as the sugar content rises and the fruit matures.

Infection on leaves appears conspicuously on the upper sides as white, powdery patches. Later, the entire surface of the leaves may be covered with the fungus. When infection is severe, the leaves will scorch or turn brown and fall. When grape cluster stems become covered with the fungus the stems shrivel and considerable losses from shelling of the fruit may occur. Black specks of the overwintering spore-forming bodies can be seen in the older affected areas.

Infection usually starts soon after the blossom period and will continue on the foliage through the growing season. The fungus develops in relatively dry conditions when the relative humidity is high.

GRAY MOLD OR BUNCH ROT

This disease, caused by the fungus Botrytis cinerea, is quite destructive on some varieties. One or more berries of a cluster show signs of decay just before harvest. The decay may progress to include most of the berries in a cluster. The infected fruit may become covered with a grayish-tan powder containing the spores of the fungus. Berry stems and cluster stems may be invaded, causing them to shrivel.

When the fungus decays berries low in sugar, the rotting berry has a sour odor and taste. If the berries are nearly mature and have a high sugar content, the decaying berry is quite firm, dry, and somewhat sweetish to the taste. Berries that have split or have been punctured often are attached by other organisms, resulting in a sour or moldy decay.

The gray mold fungus is common on all decaying vegetation. Its spores are present in the vineyard throughout the year. The first appearance in the grapevines often occurs during the bloom period when the fungus attacks the dying flower parts. Some tiny berries may become infected at this time, though decay will not be evident until near harvest. These early infection sites, often found in the centers of clusters, are a source of inoculum that can result in severe bunch rot near harvest. Fungicide programs need to be planned for both the blossom and preharvest periods for optimum control.

NEMATODES

Poor vine growth can be a result of high nematode populations feeding on the roots. Nematode injury may result in increased winter injury. One species present in Pennsylvania soils can transmit one or more virus diseases. For these reasons, soil fumigation prior to planting a vineyard may be advisable. Before fumigation is done, the soils should be sampled for nematodes and their kinds and population levels determined.

Prepared by Donald H. Petersen, Professor, Plant Pathology Extension.

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DISEASES OF TREE NUTS

WALNUT ANTHRACNOSE

This is a widespread and destructive disease of certain walnut species. The eastern black walnut is particularly susceptible. The disease is caused by a fungus that has both a sexual stage (*Gnomonia leptostyla*) and an asexual (*Marssonina juglandis*). Both stages are involved in the disease. When climatic conditions are favorable, the disease rapidly becomes epidemic and black walnut trees may become prematurely defoliated. Premature loss of leaves results in poorly-filled, low-quality, darkened kernels.

Walnut anthracnose also occurs on butternut, Persian walnut, and first generation hybrids of Persian X black walnut. While the leaves of Persian and hybrid walnuts are infected severely in wet seasons, there usually is considerably less defoliation than on eastern black walnuts.

Individual seedling trees and varieties of eastern black walnut vary in their susceptibility to walnut anthracnose. Unfortunately, even the less susceptible ones become infected severely and defoliated prematurely when the weather favors the development of the disease.

The fungus attacks the leaves, nuts, and shoots of the current season's growth. The dark brown, more or less circular leaf spots vary from 1/16- to 5/16-inch in diameter. When individual spots merge, larger dead areas form. Most leaf spots are bordered by a yellow ring. Defoliation usually follows leaf infection but sometimes the infected leaflets remain attached to the tree for much of the growing season. There is no correlation between the number of spots on the leaflet and whether or not it drops.

The spots on the walnut husks are generally smaller than on the leaves. They are sunken and they often lack the yellow border. If husk infection occurs while the nuts are very young, they do not develop normally and often drop prematurely.

The fungus overwinters in fallen leaves that were infected the previous season. It is in these leaves that the sexual stage of the fungus is formed during the winter and early spring. When mature, the ascospores are discharged from the overwintered leaves during periods of rain. They are carried to the trees by air currents. Upon landing on the undersides of young leaflets, the spores germinate and penetrate the leaflets, when moisture is present, thus initiating the disease each season. The first spores will mature and be ready for discharge by rains about the time of pollination, or when the leaves are 1/2 to 3/4 their mature size. The period of discharge lasts for about a month.

Some 14 to 21 days after infection, the spots become visible on the leaflets. It is from these initial infections that the asexual spores, or conidia, are produced. These are the sources of additional leaflet infections, as well as infections of the husks and new shoots. Spores are produced during periods of rain throughout the remainder of the growing season. Some 14 to 17 days after each prolonged wet period numerous new infections can be seen unless the initial infections are controlled.

The amount of rain and the duration of wet periods from the time of pollination up to September hold the key as to the seriousness of anthracnose on eastern black walnut each growing season. Throughout much of Pennsylvania, the average rainfall is sufficient to create conditions for heavy infections, particularly in the southeastern part of the state.

WALNUT BLIGHT

Walnut blight is caused by bacterium, Xanthomomas juglandis. It is mainly a disease of the leaves, new shoots, nuts, and catkins of Persian, black, and Siebold walnuts and butternut. Small, angular black spots, appear on the leaves, leaf stems, and succulent new shoots. The spots can become so numerous as to run together. While the disease appears destructive on these plant parts, it does not kill the tree, though it may cause some shoot dieback and some loss of leaves. Walnut blight can be destructive when it attacks the nuts. Here, the initial symptoms are small, round, elevated black spots. Often there are many running together and creating large darkened areas on the hull. These areas soon become sunken. Many diseased young nuts fall. In older ones, the bacteria invade the shell and the kernel. Both become blackened and the kernel unfit for food.

The bacteria apparently overwinter in the buds and infected shoots. About bloom time or shortly after, the overwintered bacteria multiply rapidly in wet weather. Masses of bacterial ooze from the overwintering sites to be splashed by raindrops or carried by insects to new leaves, shoots, and catkins. These first infections begin the new disease cycle. Providing these first infections can be prevented, the disease can be controlled quite well.

FILBERT BACTERIAL BLIGHT

Bacterial blight, caused by the bacterium Xanthomonas corylina, often limits production of old world filberts even where they are adapted to our late winter-early spring temperatures. Both native filberts, the American and beaked, are also attacked. They are rarely killed back severely, whereas the introduced species and their hybrids may be killed to the ground. This disease is similar to walnut blight described above, and is most damaging on twigs and branches where girdling cankers are produced. The bacteria overwinter in buds and also attack leaves and new shoot growth and weakly attack the nuts.

Prepared by Donald H. Petersen, Professor, Plant Pathology Extension.

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